THE

BEST FORAGE PLANTS

FULLY DESCRIBED AND FIGURED

WITH A COMPLETE ACCOUNT OF THEIR CULTIVATION, ECONOMIC VALUE, IMPURITIES AND ADULTERANTS, &c.

BY

DR. F. G. STEBLER,
DIRECTOR OF THE SEED CONTROL STATION, ZURICH,

AND

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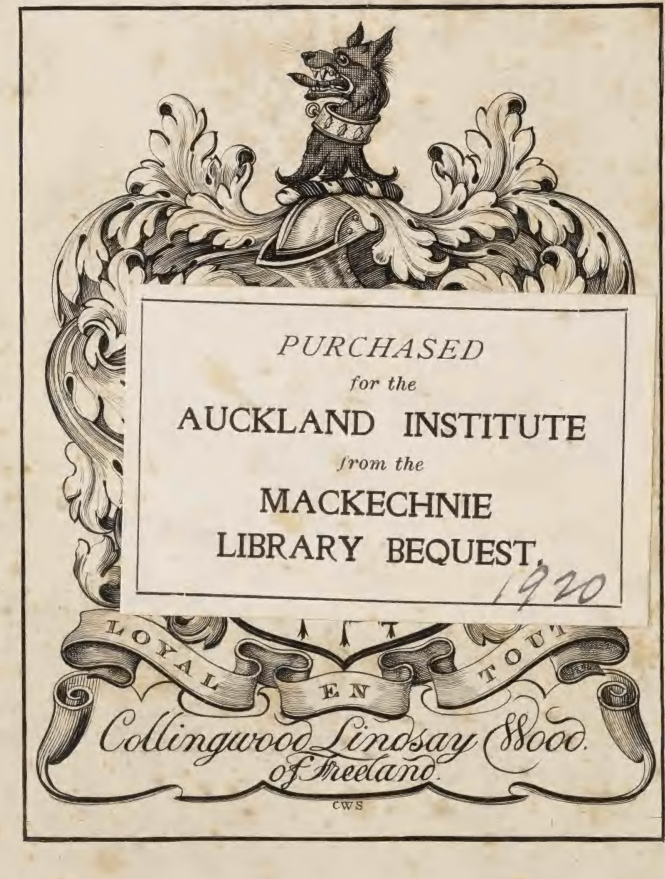
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TRANSLATOR'S PREFACE.

In 1882, at the request of the Swiss Agricultural Society, the Federal Assembly voted a grant of 10,000 francs (£400) to encourage the culture of forage. It was decided by the Department of Commerce and Agriculture, on the advice of a committee of experts, that a part of this sum should be devoted to the production of a popular manual; and the result of this decision was the present work. The author, Dr. C. Stebler, Chief of the Seed Control-Station at Zürich, is renowned, as a seed analyst and a practical agriculturist, in all parts of the world; and it is not too much to say of his treatise that it could scarcely be improved upon, whether from the point of view of the scientific botanist or from that of the working farmer, both of whom (and this is a point on which I wish to insist) may consult it with special and peculiar profit. Its quality, indeed, is such as places it beyond the reach of time; for Dr. Stebler, refraining from generalisation, and working in the true spirit of science, has differentiated some thirty types of grass and clover, and has dealt with each so completely and exactly that his analysis must remain authoritative while the types themselves exist. It is fair to add that the value of his work is immensely enhanced by the admirable plates with which it is accompanied. They are the work of Herr L. Schröter, and were produced under the superintendence of the artist's brother, Dr. Carl Schröter, Professor of Botany at Zürich, who is further responsible for the botanical descriptions in the text. The result of this happy combination is the masterpiece now for the first time presented in English, and destined, or I am greatly mistaken, to operate a revolution in the forage culture of Great Britain.

The fodder plants are just now coming in for a great deal of attention, for the British Islands are pre-eminently adapted for production, and year by year, as statistics show, the amount of land under grass is on the increase. But there has always been a great want of useful and suggestive reading on the subject, and it is proposed to meet that want by the publication of this book. Dr. Stebler deals with his material scientifically, it is true, yet with no abuse of terminology, but simply, rationally, practically—in such a way, indeed, as to be readily understood by all. There can be no question that successfully to cultivate a plant, the cultivator must of necessity have some knowledge—the more the better—of that plant's botanical peculiarities, and none that the technical point herein involved has been long an obstacle in the farmer's way. In Dr. Stebler's work the difficulty, if not entirely overcome, has been greatly lessened by the addition of Professor Schröter's illustrations, which are drawn and coloured from life, and in which the botanical features are represented so minutely and so accurately as to be instantly recognisable. Each of Dr. Stebler's thirty types is shown in its proper plate, in which is figured the mode of growth of (1) the whole plant, life size, and (2) the several parts, magnified when necessary, exactly coloured, and distinguished on an exact system of nomenclature. The points which the plates are designed to illustrate are summarised in the pages opposite, and these elucidations are supplemented by complete botanical descriptions. And in this way the farmer, even if he have no special knowledge, is enabled to pass out of the region of empiricism, and enter upon the cultivation of a plant completely equipped for success.

Dr. Stebler—who speaks on this point with uncommon experience and authority—has devoted particular attention to the impurities and adulterants which are encountered in commercial seed. The matter is as important, perhaps, as any with which the seedsman and the working agriculturist are concerned; and our author has illustrated his remarks with a great number of cuts in black and white, by whose help the student may readily detect the presence of the said impurities and adulterants, and assure himself that he is not working with unsound materials. The paramount importance of genuine seed to the farmer is obvious; and Dr. Stebler's demonstration of the precautions which have to be taken to secure good quality is absolutely clear, exact, and sufficient.

The descriptions of the several types of forage are based on a careful scheme of scientific statement. This is fully explained in the Introduction to the whole work, so that in this place it will be enough to note that reference to special points is made easy by the employment of a system of "margination" (so to speak), which enables students to take in the contents of a page at a glance.

It remains to note that the Appendix is of singular importance. It consists of four Tables, all carefully designed and executed with a view to a particular end, viz., the application of calculation to this department of agriculture. In Table I is given the amount (per acre) of germinating seed to be sown in order to procure a full crop; it enables the seedsman and the farmer easily to calculate the proportions in which to use the constituents of any mixture that may be required; and in this way it makes it difficult for those concerned to produce any but a rational mixture, or to fail to meet the requirement of a given case.* Table II shows how this is to be done, the seed (it is assumed) being of average quality. Table III sets forth the nutritive value of the various grasses and clovers, and supplies another set of data to be taken into account in determining the constituents of profitable mixtures; while Table IV gives a comparative view of the amounts of mineral matter removed from the soil.

The study of the forage plants is now a special branch of military education; and I have every reason to believe that Stebler's work will presently be found as essential a feature of the curriculum at Sandhurst and Aldershot as in those of the several agricultural and veterinary colleges throughout the country. Be this, however, as it may, I do not hesitate to affirm that, if Stebler be destined, as I believe he is, to become a power in British agriculture, the effect will be to increase the production of good forage and to considerably improve the practice of this most important branch of farming.

A. N. M'ALPINE.

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* Hitherto none but empirical formulæ have been used. But it is not doubtful that if the farmer could determine, by simple calculations, the amounts of seed by which to secure a set of definite results, the conditions of grass culture in the British Islands would very soon be changed for the better. The seedsman now knows the quality of the seeds which he supplies; and it is desirable that the farmer should require him to provide a table based on this one of Stebler's, and showing how much seed of the quality he has on sale should be sown per acre. If this were done, both seedsman and farmer would be gainers.

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INTRODUCTION.

In Europe, the production of Fodder is undoubtedly of the greatest importance. The bulk of its agricultural land, its mountains and seacoasts, its islands and peninsulas, especially in the temperate zone, is devoted to Fodder production. The same is the case in all moist countries, and year by year the land assigned to it is on the increase.

Compared with other departments of rural economy, our knowledge of Fodder plants is very limited, indeed, only in its infancy. In the past, too little attention has been paid to them, so much so, that often the ordinary farmer does not know even the names of the most valuable kinds. His notions regarding their cultivation and value are of a most primitive type. For future progress, it is essential, that this state of matters be changed.

The object of this book is to place before the agriculturist those points which are of the greatest practical importance for the production of Fodder, in order to stimulate him to closer observation and thus to advance our knowledge.

Formerly, when population was less dense than now, the rational production of Fodder was of minor importance. But now, the advance of civilization has brought about an increased demand for food, both of man and beast. Ways and means must be devised to increase the yield of Fodder, in order to obtain more flesh and milk, more manure, more grain and bread.

To solve this problem, the Economic Society of Berne, as early as 1759, offered a prize for a thesis on, »The means of increasing Fodder production by sowing indigenous or foreign grasses, adapted to the different kinds of soil«. Agricultural Societies, Governments and private individuals followed, and more rational and systematic methods of Fodder production soon began to be adopted throughout Europe. The introduction of railways, and the spread of means of communication, also forced the farmer to pay increased attention to Fodder; more of his land must be devoted to it, since now the price of grain hardly pays the cost of its production. Everyone will acknowledge that improvements in this direction must be one of the main sources of profit to the farmer. The object of the present work is to tell what is at present known of the structure, the mode of life, and the cultivation of the best Fodder plants; and so to enable the farmer to observe and experiment on his own account, and to devote himself more and more to the production and utilization of the best Fodder.

Each plant is described under the following heads:

1. Botanical description.
2. Varieties.
3. Name.
4. History of cultivation.
5. Agricultural value.
6. Geographical distribution.
7. Habitats.
8. Limits of altitude.
9. Requirements as to climate and season.
10. Requirements as to soil.
11. Mineral matter removed from the soil.
12. Manuring and irrigation.
13. Mode of growth.
14. Development.
15. Harvesting and haymaking.
16. Amount and utilization of the produce.
17. Nutritive value.
18. Harvesting the seed.
19. Yield of seed.
20. Seed impurities.
21. Seed adulterants.
22. Quality of good commercial seed.
23. Amount of seed to be sown per acre.
24. Sowing (pure or in mixtures).
25. Diseases etc.

This plan of description is followed throughout; where necessary, additional heads are introduced.

The first part of the work contains a general account of plant-life, and an explanation of the technical terms, etc., used in the special part.

GENERAL PART.

I. Botanical Description of the Natural Order Gramineae.

The body of a grass, like that of ordinary flowering plants, is made up of underground parts, bearing roots, and parts in the air, bearing leaves and flowers.

Root.

When the seed germinates, the root which is first produced is a direct downward prolongation of the stem. This, however, soon dies away, and is replaced by a number of other roots, which spring laterally from the base of the stem, more especially from those nodes, which lie beneath or near the ground. Such roots are technically spoken of as *adventitious*, and are specially prevalent among plants belonging to the *Monocotyledon* class. There is not, as is usually the case in *Dicotyledonous* plants, a direct downward prolongation of the stem forming a *tap root,* with other roots springing out along its sides.

Stem or Culm.

The stem is a *culm*, usually herbaceous and hollow. At intervals transverse plates occur; these form the swollen*) *nodes* from which the leaves originate. The hollow parts between, forming the greater part of the culm, are the *internodes.* In the internodes, the bundles of fibres and vessels *(fibro-vascular bundles)* take a longitudinal course and run parallel, leaving the centre hollow; in the nodes, the bundles cross and interlace, forming the transverse plates there. Indian Corn and Sugar Cane are, however, exceptional, as their stems are solid. The plants commonly spoken of as sedges *(Cyperaceae)* are readily distinguished from grasses by their solid stems.

Lateral branches bearing green foliage leaves can only by produced from the axils of the basal *(radical)* leaves. Other branches however which form the inflorescence towards the summit of the stem, have no leaves developed in connection with them.

Duration.

The Growth and development of the main stem and of its branches vary according as the grass is *annual* or *perennial.*

In *annual grasses* — of little importance as fodder plants — all the stems come into flower and produce seed within the space of twelve months; then the plant dies. The whole development may be accomplished in the course of a single season: — the seed germinates in spring, and by summer or autumn the fruit is ripe. At times, however, the development of an annual grass may be spread over two years: — the seed germinates in autumn, growth stops during winter but begins again in spring, and by the summer of next year the fruit is ripe.

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*) This swollen appearance is mainly due to a thickening of the base of the leaf-sheath and not of the culm itself. When laid by the wind, the culm has the power of regaining the erect position. This depends on unequal growth at the base of the leaf-sheath.

Perennial grasses have, like annuals, a main stem with branches springing from its base; but, unlike the annuals, the branches do not flower in the same season as the main stem. They remain sterile in winter, and during next season produce flower and fruit, like the main stem. Before they die, a new brood of branches, destined to continue the growth during the next period of vegetation, is produced.

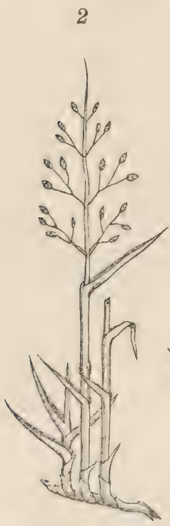

Fig. 1.

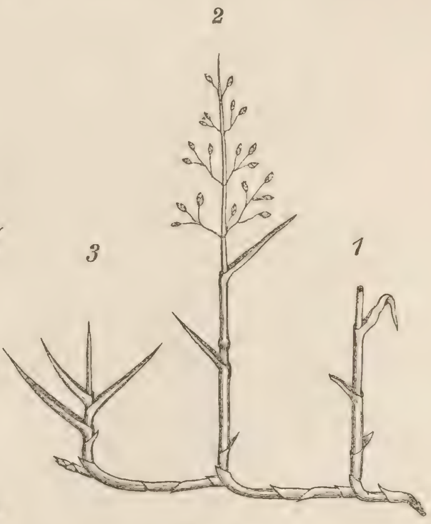

Fig. 2.

Fig. 2 is a diagrammatic representation of a perennial grass, as it would appear, say in the summer of 1886. The persisting remnant of the culm from the preceding year is marked 1. The culm marked 2 is a basal and lateral outgrowth from culm 1. In 1885 it was present as a leafy shoot, but now (in 1886) it has lengthened out, and reached the flowering stage. From its base, the leafy barren shoot marked 3 has been produced. This shoot will reach the flowering stage in 1887. At the base of 3, a lateral bud is seen; it will unfold, and form a tuft of leaves (like 3), in 1887, and reach the flowering stage, in 1888. The presence of *barren shoots*, such as 3, is a certain sign of a perennial grass*). *Moving* interferes with this typical mode of development, and causes some of the lateral shoots to develop like those of annual grasses. In Diagram 2, one shoot is represented as originating from the base of the culm, whereas, in reality, numerous shoots are produced. The *amount of produce* depends upon the number of such lateral shoots.

In perennial grasses the underground parts (Fig. 2) persist for lengthened periods; they form the *rhizome* or *root-stock.* Instead of ordinary foliage, these underground stems are provided with brown or colourless scales (Fig. 2), and the nodes are not swollen. Above ground, the dried up bases of old culms (1, Fig. 2) also persist; they, like the rhizome and the barren shoots, mark the grass as perennial.

Mode of Growth.

According to the mode of growth, perennial grasses may be divided into two groups: — 1. the tufted or *cæspitose,* and 2. the creeping or *stoloniferous.* This grouping depends upon the length of the underground parts of the branches i. e. of the parts which make up the rhizome. The branches may ascend directly above ground as in Fig. 1; the underground parts are then very short, and the aerial parts stand close together forming *tufted* grass. On the other hand, the branches may, as in Fig. 2, run for a distance horizontally beneath or on the surface of the ground; the aerial parts of such a system of branches stand widely separate, forming *creeping* grass. The horizontal portion of the branch is often spoken of as a *stolon,* and the growth as *stoloniferous.* Between these extreme modes of growth, all gradations are possible. The following terms may be applied, — *closely tufted, loosely tufted, slightly creeping, widely creeping.*

The mode of growth of tufted grasses may be further defined by the behaviour of the lateral branches. As already indicated, the branches always originate in the axils of the lower or radical leaves. Such a branch grows up, either within the leaf-sheath *(intravaginal branch),* or it bores its way through the base of the sheath which encloses it, and grows up outside of the sheath *(extravaginal branch).*

In the case of creeping or stoloniferous grasses, there must always be extravaginal branches. On the living plant it is very easy to distinguish the extravaginal and intravaginal. When they break through the sheath and are extravaginal, the base of the culm shows a number of small, white, conical, horizontal buds (Fig. 1 and 2). When the branches are intravaginal, it is necessary to remove the lower sheaths, in order to lay bare the buds which they conceal.*)

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*) These cannot be confounded with the young shoots of annual grasses. In such, when the leaves are pulled asunder, the young inflorescence, which they surround and conceal, is seen.

In considering the growth of tufted grasses it has also to be noted whether *all* the underground portions of the branches are equal in length: some may be long, while others remain quite short. If all the underground portions of the branches are equal in length, and short, a close and compact tuft of grass is produced, and as all the branches spring from a common point, the tuft is *simple e.g.* Cocksfoot, Meadow Fescue, etc.

If some of the underground portions of the branches become long, while others remain short, a *compound tuft* is produced. The whole is composed of a number of *partial tufts,* each of the latter springing from a different point of the rhizome.

Compound tufts are of two kinds. When the elongated branches of the rhizome ascend directly above ground, the partial tufts at their ends come to occupy a higher level than the others, and, at the same time, all the parts are brought close together so that the whole stands outlike a cushion, forming *compact, cushion-like tufts* of grass *e.g.* Yorkshire Fog (with extravaginal branches) and, in a less degree, Italian Ryegrass (with intravaginal branches). When the elongated branches of the rhizome run horizontally or are only slightly oblique, the partial tufts are not so close together; the compound tuft is *loose;* the cushion-like appearance is not produced, and each part of the whole resembles a simple tuft of grass, *e.g.* Perennial Ryegrass.

As will be pointed out later on the agricultural value depends largely on the mode of growth.

Leaves.

The leaves spring from the nodes. They are arranged alternately so as to form two rows lying in a plane. This arrangement is technically known as *alternate-distichous.*

The basal part of the leaf is tubular and forms a sheath surrounding the culm — the *leaf-sheath.* Usually it is *split,* but in many species *e.g.* Soft Brome, Cocksfoot, etc., it is *entire.* When split, the margins usually overlap one another; it is then described as *rolled.*

The *leaf-blade* is linear and provided with parallel veins. Between the veins**) are depressions or *furrows* which vary much in breadth and depth (see the transverse sections of the leaf-blades on plates I—XI). The raised parts are called *ribs.* Usually the blade is spread out *flat* (Fig. 3). Species, which are adapted for dry localities have the blades either permanently folded or rolled up; the lower surface is then outermost, and the blade appears more or less cylindrical. Such blades are spoken of as *bristle-like* or *setaceous* (Fig. 5). By comparing Figs. 3 and 5, the distinction between flat and bristle-like leaf-blades becomes very apparent. Fig. 4 represents an intermediate form of blade, known as *concave.*

Fig. 3.

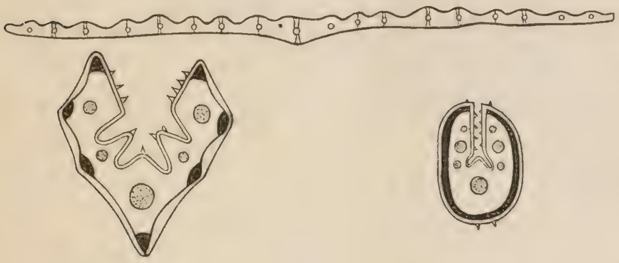

Fig. 4. Fig. 5.

Fig. 3—5. Transverse sections of leaf-blades. Fig. 3. Festuca pratensis (after Lund). Fig. 4. Festuca rubra. Fig. 5. Festuca ovina (4 and 5 after Hackel).

The culms and leaves may be more or less *rough* when pulled through the fingers or between the lips. This roughness depends upon the presence of hook-like outgrowths of the skin or epidermis. They are hard and glassy, containing a large amount of silica. According to the direction in which the points of these hooks lie, the culm or leaf is designated as *upwards rough* or *downwards rough:* in the former case, the hook-points are felt when the hand is drawn upwards, in the latter, when drawn downwards.

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*) The same distinction may be made even though the sheaths from the axils of which the branches spring have withered away. The first leaf of a branch lies next the parent stem, from which the branch has been produced, and is a mere sheath without a blade. If the branch is intravaginal, this sheath is closely pressed against the parent stem and becomes very long, and two-keeled, like the upper pale pressed against the axis of the spikelet. If the branch is extravaginal, this sheath is quite short and the keels are wanting.

**) Very rarely the furrows lie over the veins, as in Cocksfoot, Pl. III Fig. XII.

The arrangement of the leaves in the bud — the *prefoliation* or *vernation* — is of great importance in distinguishing grasses. In the bud, the blade is either *folded* (conduplicate, Pl. III, Fig. 11) or *rolled* (convolute, Pl. II, Fig. 10). The arrangement is determined, either by direct examination of the young leaves, or from a transverse section. The folded arrangement is much rarer its than the other: among fodder grasses, Crested dogstail, Cocksfoot, Sheep's fescue, Perennial Ryegrass, and Poas, have alone folded leaves.

Ligule.

The *ligule* is an outgrowth from the surface of the leaf, at the union of the sheath and blade. It is a thin transparent membrane; so to speak, a prolongation of the inner epidermis of the leaf-sheath (See Pl. I, Fig. II). The characters derived fom it are often very important in distinguishing species.

Spikelet.

The flowers of grasses always form *spikelets;* the structure is shewn in Pl. IV Fig. 1. The *axis of the spikelet* bears two rows of alternate *bracts*. The lowest pair develop no flowers in their axils and are called *glumes*.*) Each of the other bracts which produces a flower in its axil is a *lower pale*.**) A bract of peculiar structure springs from the very minute flower-stalk, from that side of it which lies next the axis of the spikelet, this is the *upper pale*.

Glumes.

The *glumes* are placed very close together on opposite sides of the axis of the spikelet, but never exactly at the same level. They are known as *lower* and *upper*. The margins of the lower overlap those of the upper, and the lower is usually the smaller; at times, both are equal in size, and the margins do not overlap (See Timothy Pl. VIII Fig. 1, and Foxtail Pl. IX Fig. 1).

Lower Pale.

The *first pale* lies directly above the lower glume, the *second* above the upper glumes, and so on. The lower pale has often a strong midrib, called the *keel* or *carina*, when there is a strong fold along the midrib, so that the halves of the bract form an acute angle like the keel of a boat. There is at times a free prolongation of the midrib; this is the *awn*. The point at which the awn becomes free from the pale varies: it may spring either from the apex *(terminal or apical awn, e.g.* Italian Ryegrass Pl. II, Fig. 4) or from the middle of the back *(dorsal awn, e.g.* Golden Oatgrass Pl. VI, Fig. 4) or from the base *(basal awn)*. Rarely, the glumes have awns *e.g.* Timothy (Pl. VIII, Fig. 1) with short awns on the glumes, and Sweet vernal grass (Pl. X, Fig. 6) with long awns on the inner glumes but none on the outer.

Upper Pale.

The *upper pale* has a somewhat different structure. Its margins are overlapped by those of the lower pale. It is not attached to the axis of the spikelet, but to the very short flower-stalk which stands in the axil of the lower pale. It is usually a delicate membrane and instead of a midrib, has a pair of *lateral ribs;* these are placed near the margins and project as keels or carinae, hence this pale is described as *bicarinate* (See Pl. V, Fig. 3).

The *number of flowers* contained in a spikelet varies much in different grasses. Timothy, Meadow foxtail, Sweet vernal, and Fiorin, have one-flowered spikelets (Pl. VIII, IX, X, XI); False Oatgrass and Yorkshire Fog, two-flowered spikelets (Pl. V, VII); Ryegrasses, Cocksfoot, Fescues etc., many-flowered spikelets. The number of flowers is readily determined by counting the lower pales, each of which corresponds to a flower.

Frequently the glumes are longer than the pales, and in that case, the latter are concealed, *e. g.* Golden Oatgrass, Yorkshire Fog, Timothy, Meadow foxtail, Sweet vernal, Fiorin (Pl. VI—XI). In other cases the pales project considerably beyond the glumes e. g. Ryegrasses, Cocksfoot, Fescues (Pl. I—V).

Inflorescence.

Before considering the flower itself, let us glance at the various arrangements of the spikelets which form the inflorescences known as *panicles* and *spikes*. When the culm produces branches which bear spikelets, the inflorescence is a *panicle*†); when the culm does not branch, and the spikelets are directly attached to a simple axis, the inflorescence is a *spike*††).

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*) Barren pales (Hackel).

**) Fertile pale (Hackel).

†) Strictly speaking a panicle of spikes.

††) Strictly speaking a compound spike.

According to the kind of inflorescence, grasses may be divided into two groups; — *1. Panicled grasses* (all the fodder grasses, except Ryegrasses), and *2. Spiked grasses* (Ryegrasses, Wheat, Rye etc.).

When the branches of a panicle are short and close together, the term *spikelike* is applied. Panicles of this kind, when bent, shew at once, that the spikelets have stalks, and that the inflorescence is really a panicle and not a spike *e.g.* Timothy, Meadow foxtail, Sweet vernal (Pl. VIII, IX, X).

Flower.

When young, the *flower* is completely enclosed and concealed by the pair of pales which goes along with it. It is composed of a pair of very minute, membranous scales, the *lodicules*, which, during flowering, become swollen and fleshy; three *stamens;* and a *pistil* with two stigmas.

The lodicules lie directly above the lower pale; they are, however, often absent (Sweet vernal, Meadow foxtail Pl. IX and X), and very rarely three are present*).

There are always three *stamens*, except in Sweet vernal, which has only two (Pl. X, Fig. 1—5), and some species of Fescue, which have only one *(Festuca myurus* and *bromoides).* One of the stamens always lies between the two lodicules, in front of the lower pale; the other two, at the sides of the upper pale. The *anther* is two-lobed, and bifid at both extremities. The *filament* is attached to the back of the anther by a mere point, situated at the basal angle of the anther lobes *(Dorsifixed versatile* anthers). The anther opens by a pair of longitudinal slits, and, once it opens, the slightest shake causes the small clouds of *dry pollen* to come out.

The *ovary* is a sessile obovate sack, which bears either on its summit or on its sides a pair of *styles.* The branches of the latter are furnished with *stigmatic papillae.* whose function it is to receive and retain the pollen i. e. to act as a *stigma.* The whole style may be covered, almost to its base with these branches *(feathery stigma) e.g.* Meadow fescue Pl. IV, Fig. 2, or the branches may be confined to the apex of the style so as to form a brush-like structure *(Penicillate stigma) e.g.* Timothy Pl. VIII, Fig. 4, and Sweet vernal Pl. X, Fig. 2. The ovary contains in its interior a single *ovule*, attached to the side lying next the upper pale *(ventral suture).*

When a flower contains functional stamens and pistil, it is called *hermaphrodite;* when the pistil is rudimentary or absent, and the stamens are alone functional, the flower is spoken of as *male e.g.* False Oatgrass (Pl. V) and Yorkshire fog (Pl. VII). In the case of many-flowered spikelets it often happens that the terminal pales are empty and contain no flower; these are called *rudiments.*

Diagram of the spikelet.

The structure of the whole spikelet can be shewn at a glance by means of the *diagram.* On such a diagram, the black dot in the middle indicates the axis of the spikelet. The glumes and pales lie along a line, to indicate that they are alternate and two-rowed. The lower down any organ occurs on the spikelet, the further it lies from the black dot indicating the axis; the glumes are thus most external, one to the right, and one to the left of the axis. Glumes and pales are represented by segments of circles, and on these the ribs are indicated by points. The lodicules are represented by very small segments of circles; the stamens, by drawings resembling transverse sections of the anthers; and the ovary, by a pair of concentric circles provided with two feathery stigmas (See Pl. I, Fig. 8). Each flower is enclosed in a pair of pales.

Flowering.

Before flowering the pales completely enclose the flower. The process of flowering goes on in three ways: —

I. The pales open widely, or rather, the lower pale moves away from the upper with great rapidity, so as to form with it an angle of 30°—50°. The stamens now appear as a small column formed of three anthers, standing upon the filaments, which are at this stage quite short. The stigmas are also erect and concealed by the anthers (See Pl. I, Fig. 1). As soon as the stamens are placed at liberty by the opening of the pales, the filaments begin to lengthen, and in a few minutes become 3—4 times their original length**).

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*) Morphologically they are usually regarded as representing a rudimentary perianth. From their development Hackel regards them as the representatives of a bifid bract.

**) Askenasy has shewn that this rapid growth is entirely due to the absorption of water from the anthers, which causes tension and stretching of the cells of the filaments.

The weight of the anthers soon causes the filaments to bend outwards and downwards. Then the anthers open and allow the pollen to escape. At the same time, the stigmas spread out right and left between the pales, and are ready to receive pollen. After fertilization, the lower pale closes on the upper, and the ripening grain is thus covered up. According to Hackel, the downward motion of the lower pale is caused by the swelling of the lodicules (due to absorption of water); they become thicker and press the lower pale down. After flowering, which lasts from 1—2 hours, the lodicules again dry up, and the elasticity of the lower pale brings it back to its original position.

II. The pales scarcely open; the stamens and stigmas protrude from a minute orifice at the apex of the spikelet. The stigmas are in this case brush-like, whereas in the former, they are feathery. When the pales do not require to open, lodicules become superfluous; they are thus absent in Timothy, and mere rudiments in Sweet vernal and Meadow foxtail.

III. The pales remain completely closed, the stamens never protrude, and the process of fertilization goes on within the closed pales — *close fertilization* or *cleistogamy*. None of the fodder grasses belong to this category, but many species of barley, some species of Stipa, and Leersia oryzoides behave in this way.

In addition to these differences in the mode of flowering, depending on the behaviour of the pales, there are other variations, depending on the mode of *pollination*. The pollen may fertilize either the stigmas of its own flowers (self-fertilization), or those of another (cross-fertilization). In the special descriptions the details relating to this are given.

Fruit.

After fertilization the ovule becomes the seed, which soon completely fills up the cavity of the ovary. It fuses so intimately with the ovary wall, now called the pericarp, that the parts can only be distinguished by microscopic observation. A *grain* of grass consists then of a seed contained in a shell or pericarp, and is in reality a one-seeded fruit. Technically it is a *caryopsis*, i. e. a one-seeded, dry, indehiscent fruit, with the seed adhering to the pericarp. By farmers and seedsmen, the caryopsis, although a fruit, is always spoken of as a »seed«; in the agricultural parts of this work it will usually be designated »seed«. In the botanical descriptions and in the explanation of the plates, the caryopsis is always mentioned as »true-fruit«. It is of little consequence whether it is designated »seed« or »fruit«. The bulk of the grain is certainly a seed, the presence of the thin outer skin or pericarp alone entitles the whole structure to be called »fruit«.

Among fodder grasses the fruit remains, at maturity, covered by the pales, but in wheat and rye, it separates from them and the grains are naked. Exceptionally, among commercial seed of Cocksfoot, naked fruits may occur; usually, however, the fruit or grass is enclosed in the pales; the glumes may also be present as in Yorkshire fog (Pl. VII, Fig. 7), and Meadow foxtail (Pl. IX, Fig. 5) and in these the whole spikelet forms the fruit. When the fruit is enveloped by pales it is called *false fruit*, to distinguish it from the *true fruit*, the caryopsis, which is formed from the ripe ovary alone. These false-fruits are aso called »seeds« in ordinary language.

At maturity, many-flowered spikelets break up into detached portions, that is to say, the axis of the spikelet breaks up into pieces, corresponding in number to the flowers. Each portion of the broken up spikelet is composed of a part of the axis, called the *stalk*, and the false fruit attached to its base. The stalk lies in front and between the two keels of the upper pale (See Pl. I, Fig. 5).

On the true fruit or caryopsis the *ventral* and *dorsal* surfaces can be distinguished; the former is next the upper, the latter, next the lower pale. At the base of the dorsal surface is the *embryo*. It occupies a depression in the albumen of the seed, and is covered merely by the thin pericarp and seed skin; hence it is so readily seen. On the ventral surface, there is often a *groove*, and at times, the *hilum* — the spot at which the seed is attached to the pericarp — can also be seen. On the caryopsis of Meadow fescue, for example, the hilum forms a longitudinal line (Pl. IV, Fig. 6).

II. Botanical description of the natural order Leguminosae.

Leaves.

The leaves of leguminous plants are usually alternate, and arranged spirally round the stem; very rarely, they are, as in grasses, alternate and two-rowed. The leaf consists usually of a distinct stalk or *petiole,* and a *compound blade* formed of several portions distinct from one another — the *leaflets.* If there are three leaflets, as in clover, the blade is *trifoliate;* if several leaflets are arranged along opposite sides of a midrib, *pinnate,* either *pari-pinnate e.g.* vetches, or *impari-pinnate e.g.* sainfoin (Pl. XV) according as an even or odd number of leaflets is present. When the leaf is pari-pinnate, the midrib often ends in a *tendril, e.g.* vetches.

At the base of the petiole a pair of lateral outgrowths, the *stipules,* always occur. The stipules are either membranous or herbaceous; they are attached to the stem by a broad base *(free),* and often also to the petiole *(adnate).*

Inflorescence.

The *inflorescence* is either a *raceme,* a *simple umbel,* or a *capitulum.* Its position is either *terminal,* at the end of a leaf-bearing stem or branch, or *lateral,* springing from the axil of a leaf.

Flower.

Each flower is always hermaphrodite and complete, i. e. it is composed of a *calyx, corolla, stamens and pistil.* It is *irregular* i. e. the parts in the same whorl are unequal in size, forming a bilaterally symmetrical structure. A regular flower such as a Tulip, is radially symmetrical, and has the parts equal in size; its perianth is composed of six equal and symmetrical parts.

The *calyx* is formed of five *sepals* cohering at the base and terminated by teeth, which are often long and acute. Usually it is irregular, as one of the teeth is longer than the others. The long tooth lies in the median line, on the lower face of the flower, next the bract; it is technically spoken of as the *anterior tooth, e. g.* Red clover (Pl. XII, Fig. 1).

The *corolla* is composed of five *petals,* unequal in size, and free from one another, except in Clovers. The largest petal is the *standard* (vexillum); it lies between the two superior teeth of the calyx; the broad terminal portion — the limb — is usually bent upwards and notched at its apex *(emarginate).* Right and left of the standard, lie the *wings* (alae), which partially overlap the keel. The *keel (carina)* is composed of two petals usually cohering more or less by their lower margins; this pair of petals lies right and left of the lower (anterior) calyx tooth (Fig. 6). In the bud, the keel is overlapped by the wings, and the wings by the folded standard.

The *Stamens* are ten; usually the nine lower cohere for a considerable part of their length by their filaments, so as to form a tube, split superiorly and surrounding the pistil. The tenth stamen fills up the slit in the tube. The *anthers* lie concealed in the apex of the keel.

The *pistil* consists of a one-chambered *ovary* containing one or more ovules, attached along the *ventral suture,* i. e. the margin of the pistil which is directed towards the standard. The ovary is prolonged into a long *style,* which is curved upwards, and terminated by a single *stigma* of variable form.

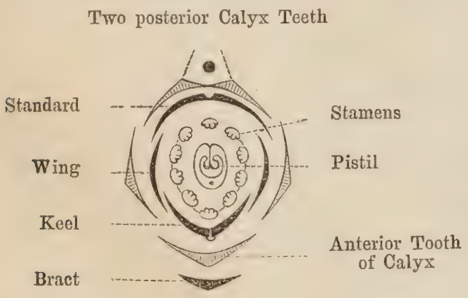

Fig. 6. Diagram of a Leguminous flower (after Eichler).

The annexed diagram of a papillionaceous flower (Fig. 6) shows at a glance the whole floral structure.

Fertilization.

As already explained, the pollen of grasses is easily shaken out from the open anthers, and is carried by the wind to the stigmas — *wind fertilization.* In Leguminous plants the arrangement is quite different. The pollen requires, for its transport, the aid of insects, which come to the flower in search of honey or pollen; these insects convey the pollen to the stigmas — *insect fertilization.* As will be explained in the special part, the arrangements for securing the attachment of the sticky pollen to the body of the insect, in such a way as to effect its transport to the stigma of another flower, — *cross fertilization**), are very varied.

Fruit.

The *fruit* is a pod *(legume)*. It opens longitudinally by the ventral and dorsal sutures, forming a pair of valves which usually become spirally twisted. The seeds are attached only to one margin of each valve — the ventral suture. At times partitions grow across the ovary; each seed then lies in a separate compartment by itself. Such a pod, when ripe, splits transversely into single-seeded portions which never open *(Ornithopus sativus)*. At times, the fruit contains only one seed; then, it either does not open at all (Sainfoin), or it splits irregularly (Red clover).

The *seed* has usually a smooth shining skin. The point at which the seed is detached from its stalk, is represented on the skin by a small, round or elliptical spot, which is dull and light in colour; this is the *hilum*. At one end of the hilum lies the *micropyle;* it appears as a very minute aperture, and marks the spot through which the pollen tube entered the ovule, in order to fertilize it; without a lens it can scarcely be seen. On the seed opposite the hilum there is a small projection, the *chalaza;* it marks the termination of the bundle of vascular tissue, which brought nutriment to the seed during its formation.

The seed skin is completely filled by the large *embryo*. There is, in this case, no albumen, and therefore the seed is termed *exalbuminous*. In a grass, the seed is *albuminous*, because it contains albumen in addition to the embryo. The two *cotyledons* form a very large part oft he embryo; they are thick hemispherical structures, closely opposed to one another by their flat surfaces, and will be the first formed seed-leaves of the young plant. The part of the embryo lying between and hidden by the cotyledons, is the *plumule;* it is merely a small bud, furnished with a few young leaves. The portion of the axis beneath the insertion of the cotyledons is the radicle; it is short and conical. It lies outside, not between, the cotyledons, and is thus often visible through the seed skin.

Germination.

When the seed germinates the radicle begins to grow, penetrates into the ground, and forms a tap-root. The plumule ascends above ground into the air, where it developes and unfolds its leaves. The behaviour of the cotyledons varies: — they either remain beneath the ground *(hypogeal)*, as in vetches; or they rise above ground *(epigeal)*, develop green colouring matter, and serve as the first foliage leaves of the plant. The latter is the case with all leguminous fodder plants, except Vetches.

Varieties. In the descriptions, the varieties referred to are mainly those of agricultural importance.

Geographical distribution. As will be seen from the descriptions in the text, the best fodder plants are indigenous to temperate Europe, very few to America.

Habitat. The habitats give some notion of those kinds of soil which are naturally adapted for the cultivation of the respective plants.

Limits of altitude. Most fodder plants can be grown at considerable elevations, some thriving even in Alpine regions. Knowledge of these altitudes is very useful, especially in mountainous districts.

Climate. Except Sainfoin and Lucerne, fodder plants, as a rule, thrive best in humid climates, and in moist seasons, provided that the temperature is suitable. Maritime and mountainous districts are thus best adapted for the growth of fodder.

Soils. In the descriptions, the following types of soil are referred to: —

1. Strong clays.
2. Clays.
3. Mild clays.
4. Clay loams.
5. Loams.
6. Sandy Loams.
7. Loamy sands.
8. Loose sands.

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*) In some cases it is certain that the pollen can fertilize the stigma of its own flower, in many other cases thi is doubtful.

Soils.

Of these 1 is the most tenacious and compact; the others, in their respective order, become lighter and looser. The loam (5) is the normal type of soil. The following are also referred to: —

9. Clay marls	containing	50—60%	clay	and 10—15%	carbonate	of	lime
10. Loamy marls	,,	35—50%	,,	and 25—50%	,,	,,	,,
11. Calcareous marls	,,	20—35%	,,	and 50—75%	,,	,,	,,
12. Sandy marls	,,	60—80%	sand	and 10—20%	,,	,,	,,

Nos. 9 and 10 approach the loams, while 11 and 12 are easily dried up by the sun, and the vegetation thereby burned and destroyed.

The following are also distinguished: —

13. Clayey calcareous soils.
14. Loamy ,, ,,
15. Sandy ,, ,,
16. Gravelly or stony ,,
17. Good sweet humus soils.
18. Peaty soils.
19. Rich heath soils.

Most soils contain humus, and according to the amount can be classified as follows: —

a. Poor in humus, with	3%	humus.
b. Containing humus, with	3— 5%	,,
c. Humous, with	5—10%	,,
d. Rich in humus, with	10—15%	,,
e. Very rich in humus, with	15 and more	,,

A humous sandy loam, for example, means a sandy loam containing 5—10 % humus. A soil containing iron sufficient to give it a deep red colour, is called *ferruginous;* if, in addition to the iron, it contains acid humus, it is a *barren* ferruginous soil.

To indicate the *amount of moisture,* the following terms are used: — *arid, dry, humid, moist, wet.*

According to their mode of formation, soils are either *indigenous,* the weathered products of the rocks upon which they lie; or *alluvial* i. e. transported from a distance. The terms *fertile* and *barren* are applicable to all kinds of soil.

Manure.

Substances removed from the soil — Manure. The data, given in the special descriptions under this head show that the different kinds of clover and leguminous plants remove from the soil much more potash, lime, and magnesia, than grasses. In the ash of the latter, however, the proportion of silica is much larger than in the former. It is not necessary to return to the soil all the substances removed from it, as some are present in abundance. In the manure, it is only necessary to return the *nitrogen, phosphoric acid, potash,* and, more rarely, *lime.* On soils of ordinary types, the humus and the humus-forming constituents of the manure, are also of importance, and are always abundant in farmyard manure. In order to determine experimentally what nutritive substance is absent, or present only to a minimum extent in the soil, *Heinrich**) recommends the following trials: —

1st Plot: Potash.
2nd ,, Gypsum.
3rd ,, Phosphoric acid (Superphosphate).
4th ,, Nitrogen, in the form of dried blood ground into powder.
5th ,, Potash and Phosphoric acid.
6th ,, Potash and Nitrogen.
7th ,, Phosphoric acid and Nitrogen.
8th ,, Phosphoric acid, Nitrogen and Potash.
9th ,, Without manure.

The substance applied to that plot, from which the largest yield is obtained, is at a minimum in the soil. If the largest yield is obtained from plots 1—4, only one nutritive substance is at a minimum, if from 5—7, two substances, and if from the 8th plot, the three most important substances are required. In such experiments, it is, of course, necessary to apply equal quantities of the same nutritive substances to the different plots.

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*) Heinrich, Grundlagen zur Beurtheilung der Ackerkrume in Beziehung auf landwirthschaftliche Pflanzenproduction. Wismar, 1882.

In the case of grasses, liquid manure usually gives the best results. If *an artificial manure* is to be used, it should first be spread on the ground; the application of the liquid will then wash the manure into the soil. It is not advisable to use *farmyard manure* while the plants are in active growth, because, when harvested, the fodder would be rendered impure thereby. Its use, immediately after the last cutting at the end of summer or in autumn, is preferable.

From experiments conducted on a large scale by *Lawes and Gilbert**), and extending over a period of twenty years, very important results have been obtained. The following are most noteworthy:

1. In the case of grasses, any manure, whether natural or artificial, reduces the number of species.
2. Nitrogenous manures act most beneficially on grasses, while potash manures are most beneficial to leguminous plants.

Growth.

On good grass land, it is essential that the plants cover the ground *uniformly*, and produce a *complete sward*. Plants forming *compact cushion-like tufts* (see page 5) should be kept out. For this reason, Yorkshire Fog is bad; it produces compact cushions of very unsightly grass which interfere with the scythe, and do not allow a uniform cut to be obtained. Grasses like Cocksfoot and Meadow fescue, which form *simple compact tufts* cannot by themselves form a complete sward — gaps must occur between such tufts. The same is the case with most clovers. By mixing with these other plants capable of filling up the gaps, a complete sward may be obtained. For this purpose, grasses which form loose tufts (False oat-grass, Timothy, Yellow oat-grass etc.), may be used. These, however, have this drawback: — they produce an open sward. The best plants for completing the sward — for covering the ground thickly and uniformly — are those which are stoloniferous, as Rough-stalked meadow-grass, Smooth-stalked meadow-grass, Fiorin, White clover etc. It must, however, be borne in mind, that there are all gradations between these modes of growth, and these should always be taken into account in laying down mixtures for fodder production. Meadow foxtail, for example, stands midway between the stoloniferous and the loosely tufted grasses.

Development. The rate at which fodder plants develop varies with the species. Some reach their full development even in the first year, others only in the third. For short leys, therefore, those grasses are selected which develope rapidly, but for permanence, those that develope more slowly and have a longer duration. All leguminous plants, except Sainfoin, mature very rapidly, and give a full yield in the first year, unless when grown with a cereal crop.

Hay-making.

Harvesting. Fodder plants are used either green or dry. Little need be said about green fodder, but it is necessary to explain, at least in principle, the different methods of making dry fodder or hay.

1. *Drying by the sun.* This is the usual plan. After cutting, the grass is spread out, and allowed to dry in the sun. While drying, it is turned once or oftener; in the evening, it is formed into foot cocks, and next morning, again spread out. This is the simplest and cheapest process, but can only be practised in favourable weather.

2. *Brown Hay.* This process is used especially for clovers, which in the green state contain about 10 % more water than grasses. They are, therefore, more difficult to dry. When in flower, red clover contains about 80 % of water; when made into hay, only 16 %. During drying, therefore, 64 % of water requires to be evaporated. If dried by the sun, evaporation goes on very slowly, and frequent handling, which causes considerable loss of leaf, is necessary. To avoid these difficulties, brown hay is made. The cut plants are dried in the sun, till 35 or 40 % of the contained water has evaporated. While exposed to the drying action of the sun, the plants are only turned once. Large cocks *(pikes)* are now formed. These become strongly heated, and this heat completes the evaporation and drying. After 5 or 6 weeks, the hay is housed, and usually no further handling is necessary.

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*) Lawes and Gilbert on »The effect of different manures on the mixed herbage of Grass-land.« Journal of the Royal Agricultural Society of England, vol. XXIV, part I.

The first and second methods of making hay are often combined. When the season is unfavourable, the partially dried hay is formed into round cocks, of variable size, and as compact as possible. In this way, less rain has access to the hay. Suppose that the rainfall during the day is 2 inches i. e. 7260 cubic feet of water per acre. If the hay is spread out so as to cover the whole ground, 7260 cubic feet of water pass through it, and thereby a large amount of nutriment is washed out and lost. If the hay is in cock, it covers say only $^1/_{50}$th part of the whole ground. Only 145 cubic feet of water touch it, and the loss of nutriment is consequently 50 times less than before. Wolff states that cold water passed through clover hay extracts 25—40 % of the dry substance. 100 lbs. of hay, therefore, may lose 21—34 lbs. of the dry substance. The following result was obtained at Möckern:

Hay not exposed to rain	36.1 %	Non-nitrogenous extractives and fat.
Hay exposed to rain for 14 days	23.4 %	

To obtain hay of good quality and high nutritive value, it should be made into cock, whenever rain is feared. Under rain, the cocks become heated. The temperature to which the cocks rise depends upon the size, the compactness, and the proportion of water in the fodder. In fine weather, the cocks are spread out, and the hay very readily dries. As already pointed out, this mode of procedure is a combination of drying by the sun and *piking* (brown hay). It has been in use in Switzerland, and other countries, for more than a century.

3. *Air-Dried Hay.* Under this head may be placed all those processes in which drying is brought about by a current of air. This may be done either by arranging the plants simply on the ground, or on wood scaffoldings. When the former plan is used, the plants are cut with the scythe and made into sheaves (Fig. 7) similar to those of cereals. After drying for 2—3 days in the swathe, small sheaves are formed, with the partially dried plants in the centre. The sheaves are bound, by means of a few culms, close beneath the inflorescence, and the cut ends placed on the ground (Fig. 7). When the plants are cultivated for seed, another kind of sheaf is used, in order to allow the ripening process to go on after cutting. In this case, sheaves as thick as the arm are formed; 100 or more of these are placed together, so as to form a large compound sheaf (Fig. 8). These are allowed to stand from 8—14 days. For Red clover and Lucerne stooks are used as in Fig. 9. The plants, after drying somewhat in the swathe, are arranged so as to form two long rows, opposite to one another. Sheaves and stooks are readily overturned by the wind. When this happens, they must be set upright; this often causes much labour.

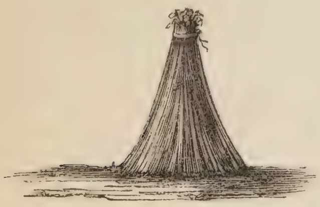

Fig. 7. Sheaf.

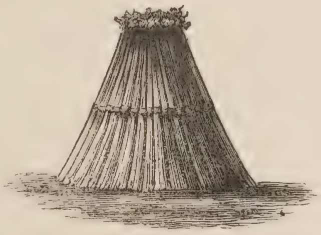

Fig. 8. Compound sheaf.

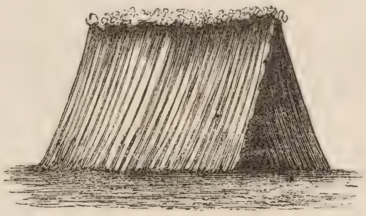

Fig. 9. Stook.

In mountainous districts where the heat of the sun is insufficient to dry the hay, it is placed, after partial drying, on *perches* with crossed arms (Fig. 10). In this way, the air obtains free access, and the plants are thoroughly dried. Because of the difficulty in transporting and fixing the perches in the ground, *Schwerz* has recommended another kind of carrier. It consists of three trestles, bearing three horizontal bars, on which the clover is placed (Fig. 11). The best drying apparatus, however, is the *pyramid* (Fig. 12) which recently has come into more extended use. Whatever kind of carrier is used, the fodder is

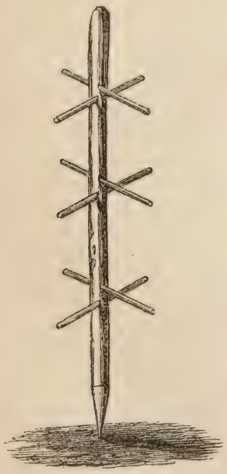

Fig. 10. Perch.

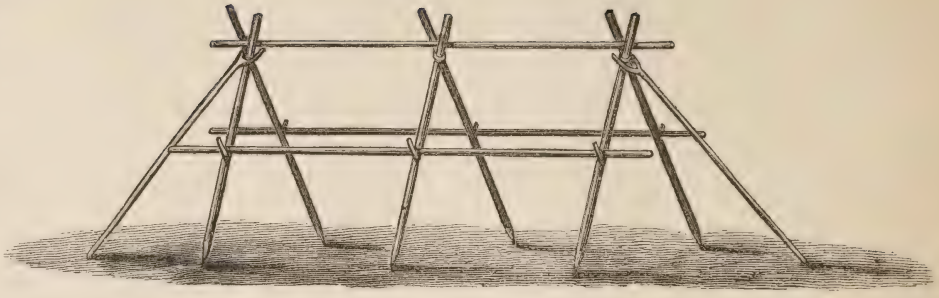

Fig. 11. Clover carrier.

only placed upon it, after it is partially dried. The principle underlying all these air drying apparatuses is this, that an interval must occur between the fodder and the ground to allow free access of air beneath. Two or three days are required for drying, but on pyramids, longer time (6—10 days, according to the weather) is necessary.

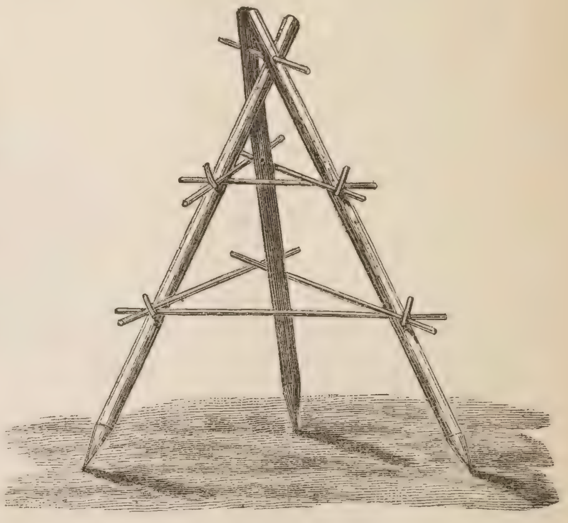

Fig. 12. Pyramid.

Silage.

Ensilage. In moist climates and seasons the process of ensilage is now coming into use for preserving cut grass. In this process, the grass is placed either immediately after cutting, or after a few hours exposure to the air, in a silo and closely covered so as to prevent access of air, and, to a certain extent, decomposition.

In wet climates where grass is very difficult to convert into hay, ensilage may with advantage supplant hay-making as a means of obtaining winter forage. In drier climates having occasional wet or late seasons, or in those yielding a second crop too late for hay-making, it could also be used. Even in good seasons and climates, where hay-making can be relied upon, ensilage will be of great benefit, because rough, coarse and unpalatable grasses are thereby rendered more succulent and palatable. The chief benefits of ensilage are: —

1. In wet seasons, it prevents waste of grass.
2. It converts coarse, woody grasses, otherwise of little value, into succulent and palatable food.
3. When given to dairy cows in winter, it increases the quantity of milk. Butter, from cows fed on good silage, has the quality, colour, and flavour, that pertain to it in summer.
4. It saves the short grasses which are lost in hay-making.
5. In the case of clover and »clover grass«, the leaflets which are the most valuable parts of the clover plant, are saved, whereas in ordinary hay-making they readily break off and are to a large extent lost.

Silos.

The silo may consist of a pit dug in the earth; a pit with a part above ground; or a building wholly above ground. The whole should be arranged so as to exclude air. The roof is capable of being moved, to allow the application of pressure to the contents. If a pit is dug it should be well drained, both at the sides and bottom, but not so freely as to permit access of air. The presence of excessive moisture causes the development of moulds. The walls and floor may be made of concrete, stones or earth. If a building is used as a silo, the door, if present, should be as air-tight as possible. When the silo is filled all at once, the after-shrinkage is considerable; it is therefore advisable not to close it permanently until more grass etc. has been added to fill up this space. The roof may be of zinc, iron or Willesden paper. Pressure may be applied by lever, screw, barrels filled with stones or water, or a water tank may be used. The number*) of silos in Great Britain, in 1884, was 610, having an average capacity of 3,052 cubic ft.; while in 1885 the number was 1,183 having an average capacity of

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*) Replies to questions relating to Silos and Ensilage, 1885. London: Eyre and Spottiswoode.

2,801 cubic feet. These data show that the practise of ensilage is increasing and that the small silo is coming into favour.

In Britain, meadow grass, clover, trefoil, and aftermath have been principally used for silage. Oats, green barley and wheat, maize, buckwheat, sainfoin, rye vetches, lucerne, hop-bine, mangel and turnip tops, spurrey, peas and beans, and rough grasses have also been tried with success.

The crop is put into the silo either chaffed or unchaffed. If chaffed it goes into less bulk and is likely to be more uniform in quality, but the expense is greater.

The crop for ensilage should be taken somewhat earlier than for hay-making, at a time when the juices in the stems and leaves are most abundant. Some hours' exposure to the atmosphere and sun is necessary if »sweet« silage is desired; when this is not attended to, »sour« silage results. After filling, time should be allowed for shrinkage, then additional herbage is added until the silo is quite full. The roof is now adjusted and weighted.

All kinds of stock have been tried on silage and have done well. Sometimes they refuse it at first especially when it is sour, but soon they become ravenously fond of it.

It is particularly suitable for dairy cows, as it supplies the place of fresh grass in winter. The silage increases the quantity of milk without injuring the colour or quality of the butter.

Nutritive value. The nutritive value of a fodder depends upon the amount of nitrogenous and non-nitrogenous assimilable nutriment which it contains. The nutritive matter in plants is either nitrogenous or non-nitrogenous; according to the prevailing opinion, the nitrogenous nutriment is *albumin;* and the non-nitrogenous, *fat, woody fibre* and *extractive matters.* It is sometimes considered that *one part of assimilable albumin or of fat is equivalent in money value to 5 parts of assimilable woody-fibre* or *non-nitrogenous extractives.* If the amount of assimilable nutriment contained in fodders is known, it is very easy to determine the relative money value on this scale. Suppose, for example, that 100 lbs. of Perennial Rye grass hay contain: —

Assimilable albumin	5.1 lbs.	× 5 =	25.5 units of value,
do. fat	0.8 »	× 5 =	4.0 do.
do. carbohydrates (= extractives + woody-fibre) . .	35.3 »	× 1 =	35.3 do.
		Total	64.8 units of value.

Suppose 100 lbs. (roughly 65 units of value) of this hay cost 3 shillings, 1 unit of value costs 0.55 pence i. e. a little over $^1/_2$ d. Average meadow haycontains 73 units value; of if 100 lbs. of this cost 3 shillings, Perennial rye-grass hay should cost only $\frac{(3 \times 65)}{73} = \overset{s}{2}\,|\,\overset{d}{8}$

The total amount of nutriment contained in a fodder, is readily determined by chemical analysis, but the proportion which is assimilable is not so easy to find. Chemists have determined, for example, that 100 lbs. of green dandelions (87 % water) contains 2.6 lbs. of albumin, 0.5 lb. of fat, 6.0 lbs. of extractives and 1.9 lbs. of woody fibre; but the amount of each of these constituents which is assimilable, can only be found by experiments made upon animals fed with the dandelions. To find the amount of assimilable nutriment, the fodder used, and the solid excrements of the animal must be weighed and analysed; the difference represents the amount assimilated. Suppose that 2.6 lbs. of albumin have been given to the animal, and that 1.3 lbs. are found in the excrements, then 2.6—1.3 = 1.3 lbs. of albumin are assimilable, or, the *coefficient of assimilation* for albumen is 50. The amount assimilated varies according to the species of plant which is used, its stage of development, etc. For example, a larger percentage of nutriment is assimilated from young grass than from the same grass when ripe. Well-got hay has the same advantage: the proportions of nutriment assimilated from it are much higher than those from hay deteriorated by rain. From dry fodder, on an average, 40—80 % of the total albumin can be assimilated, and 30—60 % of the fat. Non-nitrogenous extractive matters are considered as completely assimilable, and as compensation for the error introduced by this assumption, the woody fibre is regarded as non-assimilable. Non-nitrogenous extractives and woody fibre are spoken of together as *carbohydrates*. Resuming the case of the dandelion, suppose that 70 % of the albumin and 50 % of the fat are assimilated, the actual percentage of assimilated nutriment is

Albumin	1.8 %
Fat	0.25 %
Carbohydrates	6.0 %

100 lbs. of green dandelion contain, supposing these figures correct, 16 units of value calculated as above.

The amount of albumin in fodder, has, till now, been determined simply from the amount of nitrogen found by chemical analysis; the amount of nitrogen × 6.25 = albumin. This assumes that all the nitrogen in fodder is present as albumin. If, for example, 2 % of nitrogen is found, then 2 × 6.25 = 12.5 % is considered as albumin. Analysis has shewn that 6.25 parts of pure albumin contain 1 parts of nitrogen; hence the use of the multiplier 6.25. Recent researches, however, tend to show that a large percentage of the nitrogen occurs, not in the form of albumin, but as amides, asparagin for example. What value these amides have for feeding purposes has not as yet been determined. It would appear as if they could partly replace the albumin, when used along with it. In these pages, then, the nitrogen is still regarded as representing albumin. When the nutritive value of the amides has been experimentally determined, it will be necessary to mention them separately in data regarding the composition of fodder. Since so little is at present known regarding them, it is useless to take them into account; nevertheless, when known, the amount of amides present in a fodder is stated in the body of the work.

The ratio of the assimilable nitrogenous to the assimilable non-nitrogenous nutriment *(albuminoid ratio)* remains to be noticed. In this ratio the value of fat is taken as 2.44 times that of the carbohydrates. In the case of Perennial Rye-grass hay it is $5.1 : 35.3 + (0.8 \times 2.44) = 1 : 7.3$.

According to Wolff, stock require, per 1000 lbs. of live weight, the following amounts of nutriment daily: —

Kind of animal	Total amount of organic matter	Assimilable matter				Albuminoid Ratio.
		Albumin	Carbohydrates	Fat	Total	
	lbs.	lbs.	lbs.	lbs.	lbs.	
1. Oxen at complete rest in stall . . .	17.5	0.7	8.0	0.15	8.85	1 : 12.0
2. Sheep fed for wool. Stronger breeds .	20.0	1.2	10.3	0.20	11.70	1 : 9.0
,, ,, ,, ,, Finer breeds . .	22.5	1.5	11.4	0.25	13.15	1 : 8.0
3. Oxen at moderate work	24.0	1.6	11.3	0.30	13.20	1 : 7.5
,, at full work	26.0	2.4	13.2	0.50	16.10	1 : 6.0
4. Horses at light work	21.0	1.5	9.5	0.40	11.40	1 : 7.0
,, at moderate work	22.5	1.8	11.2	0.60	13.60	1 : 7.0
,, at full work	25.5	2.8	13.4	0.80	17.00	1 : 5.5
5. Milch cows	24.0	2.5	12.5	0.40	15.40	1 : 5.4
6. Fattening oxen, 1st period . . .	27.0	2.5	15.0	0.50	18.00	1 : 6.5
,, 2nd ,, . . .	26.0	3.0	14.8	0.70	18.50	1 : 5.5
,, 3rd ,, . . .	25.0	2.7	14.8	0.60	18.10	1 : 6.0
7. Fattening sheep, 1st period . . .	26.0	3.0	15.2	0.50	18.70	1 : 5.5
,, 2nd ,, . . .	25.0	3.5	14.4	0.60	18.50	1 : 4.5

This table shows the amount and proportion of the different kinds of nutritive substances required by our domestic animals.*)

Impurities and Adulterations of Seed. *Adulterants* are foreign bodies, artificially mixed with a seed for purposes of gain; *impurities,* on the other hand, are ingredients which occur accidentally. *Dodder* and *Pimpernel* are, for example, impurities and not adulterants, because they are not intentionally added to the seed. If coloured stones occurred, they would constitute adulterations.

Quality of Seed. The quality of seed is in general determined by the *purity,* the *germinating power,* the *size of the seed,* and the *weight per bushel.* The higher the purity, germination and weight per bushel, and the larger the grain, the more valuable is the seed. By *purity* is to be understood the percentage of pure or true seeds contained in a sample; by *germinating power,* the percentage of the pure seeds which can germinate or grow. A statement that seed has 90 % purity and 80 % germinating power, means that only 90 % of the whole is pure seed, and that only a portion, 80 %, of the pure seed germinates When the purity (P) and germinating power (G) are known, it is easy to calculate the percentage of pure and germinating seed: — the purity is multiplied by the germinating power, and the product divided by 100 or $\frac{P \times G}{100}$ = percentage of pure and germinating seed. The impure portion of the seed has no value, neither have those seeds which cannot germinate; the pure and germinating part of the seed alone has value, and the percentage indicating this determines the *real value.* The real value of a seed whose purity is 90 % and germination 80 % = $\frac{90 \times 80}{100}$ = 72 %. In the same sense, we speak of 10, 20, 30 to 100 % seed. 100 % seed has no impurities (purity = 100 %), and all its seeds germinate (germinating power = 100 %). Seeds of fodder plants have never this full value. Even the best qualities contain impurities such as earth, debris of seed, etc.; and very seldom do all the pure seeds germinate.

In speaking of the seeds of the different fodder plants, that purity and germination, which indicate seed of good quality, is always given. For example, good perennial rye-grass should have 95 % purity and 75 % germinating power = 71.25 % real value. The weight of the useful seed (i. e. of the seed which is pure and germinating) is easily found, when the *real value* is known. For example, if a bag contains 4 lbs. of 2 % seed, only $\frac{2}{100}$ of the whole is useful, therefore the weight of the useful seed is only $\frac{8}{100}$ of a lb. If a bag of 80 % sainfoin weighs 50 lbs., then the weight of the useful seed is $\frac{50 \times 80}{100}$ lbs. = 40 lbs.

The price that should be paid for seed can readily be calculated, when the real value is known. If 1 pound of 90 % seed cost 9d., one pound of perfectly pure and germinating seed (real value = 100) should cost $\frac{100 \times 9}{90}$ d = 10d. If 70 % seed cost 9 d. per pound, one pound of the pure and germinating seed should cost $\frac{100 \times 9}{70}$ = 12.85d.

The seed becomes more valuable as its *size* increases. When the grains are large, fewer make a pound. In the description, the *number of seeds in a pound* has been obtained from a large number of

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*) The distinguished agricultural chemist *Adolphe Meier* of Waageningen, Holland, has shewn that the nutritive value of a plant cannot be determined from its chemical analysis alone. Some plants notoriously bad would appear from their chemical analysis to be very nutritive; while others, well known as excellent, would seem from their composition inferior to the former. The experience of agriculturists must be taken into account in determining whether a plant constitutes suitable and nutritive fodder. The results of the chemical analysis of the good fodder plants are, however, comparable, and determine in a general way the comparative nutritive value.

weighings. When the number of seeds per pound is high, it indicates that the seed is small, and of less value than if the number of seeds per pound were less.

In the same way the *weight per bushel* may be taken as a measure of the value of seed. In general, as this weight increases, the value of the seed also increases.

Amount of seed to be sown per acre. The amount of perfectly pure and germinating seed required to cover an acre of ground is always given under this head*). From this, the weight of commercial seed which is required, can readily be calculated, when its purity and germination are known. At the same time, the average amount of commercial seed of good quality which should be used, is also given. For example, the quantity of perfectly pure and germinating seed of Perennial rye-grass required to cover an acre of ground is 38½ lbs. That is equivalent to 54 lbs. of commercial seed, whose real value is 71 % (purity 95 %, germination 75 %**).

If a mixture of seeds is to be made, the proportion of ground to be allotted to each kind of plant is first fixed; the weight of each kind of seed can then be calculated from the tables in the appendix. Suppose that a mixture of perennial rye-grass and white clover has to be made, so that 50 % of the ground is to be covered with perennial rye-grass, and 50 % with white clover. For this purpose 19 lbs. of perfectly pure and germinating seed of perennial rye-grass = 27 lbs. of commercial seed having 71 % real value, and 3¾ lbs. of pure and germinating white clover seed = 5¼ lbs. of commercial seed having 74 % value, should be used per acre.

From grass land, the farmer wishes to obtain the maximum quantity of good animal nutriment. By sowing one kind of plant, the maximum produce is rarely obtained, either because the plant cannot cover the ground completely, or, if it does, only a small proportion of the produce is above ground since plants which can grow in this way are usually stoloniferous. The largest produce is in general to be obtained by mixing, in proper proportions, those grasses and clovers which are most appropriate to the soil.

The plants most suitable for forming mixtures, which will cover the ground most completely, can readily be determined from the information given under the heading »*Growth*« in the special part of the work. It is very important that deep and shallow-rooted species are represented in such proportions that the roots fill up and utilize all the ground. The parts above ground form *Top*, *Middle*, and *Bottom* grass; each of these kinds should have a due proportion of ground allotted to it. The duration, rate of growth, as well as other special characters should also be taken into account. Space is too limited to explain further the principles on which the composition of plant-mixtures depends. Full details and numerous examples are given in Stebler's special work on »The mixing of grass seeds«.

When the proportion of ground to be assigned to each species of plant has been fixed, it is easy by means of the tables in the appendix, to calculate the weight of each kind of seed which should be taken to form the mixture.

On a surface of a given size, there is room for a greater number of plants of different species, than when a single species is grown by itself. The number of plants required becomes greater, as the species composing the mixture become more numerous and diverse in character. That is why, in the tables, the quantity of seed for a pure sowing is given in a separate column. For mixtures, additions varying from 10 to 80 % are made (See the tables).

When a mixture is to be laid down, the plants most suitable are first selected, then the proportion in which each kind is to be represented is fixed, and lastly, the additional percentage over a pure sowing is determined. Further detail is unnecessary here.

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*) Data for these calculations are given by a great number of agricultural writers.

**) $\frac{38.5 \times 100}{71} = 54.$

The following example shows how a 2 to 3 years' ley of a clover grass mixture is reckoned: —

Kind of Seed	The mixture to consist of	Addition to pure sowing	Weight of each kind of seed in the mixture per acre.			
			Perfectly pure and germinating seed	Commercial seed		
	%	%	lbs.	lbs.		
1. Red clover . .	40	10	7	8	containing 88 %	Pure and germinating seed.
2. Alsike clover . .	30	10	3	4	„ 73 %	
3. Italian Rye-grass .	10	10	$3^{1}/_{2}$	5	„ 67 %	
4. False Oat-grass .	10	10	$3^{1}/_{2}$	7	„ 49 %	
5. Timothy . . .	10	10	$2^{1}/_{2}$	3	„ 87 %	
Total	100		$19^{1}/_{2}$	27		

This mixture of clover grass contains 40 % of Red clover. The absolute amount of pure and germinating red clover seed required to cover an acre is 15.84 lbs. (see table 1): an addition of 10 % makes 17.42 lbs.. The mixture should then contain $\frac{17.42 \times 40}{100}$ lbs. = 6.97 = nearly 7 lbs. of pure and germinating seed. Commercial seed has been taken as containing 88 % pure and germinating seed, therefore $\frac{7 \times 100}{88}$ lbs = 8 lbs., nearly, of such commercial seed is required. The other calculations are made in the same way.

Preparatory crop, Preparation of the ground, Covering the seed, Time of sowing, Sowing, Protective crop. The best *preparatory crops* for all fodder grasses and clovers are such as leave the field well manured, and as clean as possible. These conditions are best fulfilled by a well manured root-crop.

Grasses as well as clovers require a fine tilth, because, without this, many of the seeds fall between clods and lie too deep, so that the young plants which spring from them are lost.

The covering of the seed ought to be very slight, for the reason that many grasses, especially those of the finer kinds, will not grow when at all deeply covered. On heavy humid soils no covering is necessary, and rolling suffices; on light dry soils, the seed may be covered by means of a light harrow.

In general the spring months from April to the middle of June, are most favourable for sowing; Autumn sowing is, however, often resorted to, but the results are less satisfactory.

Sowing is performed by hand, or by the clover-drill, which can be used for all kinds of grasses except False oat-grass.

Grasses and Clovers are usually sown in a protective crop, very frequently in winter-wheat, in the months of February or March. At times, spring-wheat or cereals to be cut green (oats or rye) form the protective crop.

Full information on all these points is given in Stebler's work on »*The Mixing of Grass-seeds*« already referred to.

For the botanical descriptions, the following works of reference have been used: *Ascherson:* Flora der Provinz Brandenburg. Berlin 1864. *Döll:* Flora des Grossherzogthums Baden. Karlsruhe, 1857—1862. *Nymann:* Conspectus Floræ Europææ, Oerebro. 1878—1882.

Godron: De la floraison des Graminées, Memoires de la société nationale des sciences naturelles de Cherbourg Tome VII p. 105 (1873): also Reinpau, das Blühen des Getreides. Landw. Jahrbücher von Thiel, 1883, p. 875.

SPECIAL PART.

I. Perennial rye-grass.

Lolium perenne L.

Explanation of plate.

Fig. A. Entire plant in flower, shewing two spikes, and two partial tufts of grass united by two short stolons.

,, 1. The spikelet in flower, with a portion of the axis of the spike. The spikelet in the figure is composed of 6 flowers with their pales, and a single glume. The 1st or lowest flower lies to the left, the 2nd to the right, and so on alternately. The 1st and 2nd are in full flower with the stamens and stigmas protruding; in the 3rd, the pales have just opened; the others have not yet flowered.

,, 2. The pales before flowering, from the ventral surface, shewing the upper pale. The lower pale partially overlaps its margins and is longer. The stalk is a portion of the axis of the spikelet.

,, 3. The same, from the dorsal surface, shewing the 5-ribbed lower pale.

,, 4. The false fruit (seed), dorsal surface, shewing the lower pale.

,, 5. The false fruit, ventral surface, shewing the broad, flat stalk, which tapers to the base. The enlargement of the ovary to form the grain, has pushed out the upper pale, and laid bare its ciliated keels (compare fig. 2).

,, 6. The caryopsis or grain, ventral surface.

,, 7. The caryopsis, dorsal surface, shewing the embryo.

,, 8. Diagram of a spikelet composed of 6 flowers as in fig. 1, 5 complete, and 1 rudimentary.

,, 9. Transverse section of a young leaf-blade, shewing the folded vernation.

,, 10. Transverse section of the fully developed blade, shewing the acute ribs (after Lund).

,, 11. The short, obtuse ligule of a culm leaf.

Botanical description.

Botanical description. Perennial rye-grass forms large, compound tufts of grass. The partial tufts stand close to one another in the ground and form a compact sward. The lateral branches are intravaginal. Here and there internodes beneath the ground elongate, and form short, slender, horizontal or slightly ascending stolons. The whole tuft is thus composed of numerous partial tufts bound together by these short stolons. Externally, at the base of each partial tuft, red persistent leaf-sheaths are seen. These old sheaths do not decompose and split up into fibres, as is often the case with other grasses. The *culm* is smooth and reaches a height of 1 or 2 ft. The *leaf-blade* is dark green, folded when in bud, ribbed on the upper, but not on the lower surface; the margins are somewhat rough. The *ligule* is very short. The *inflorescence* is a spike composed of one terminal, and many lateral spikelets (fig. A). The latter are seated in notches of the axis (fig. 1), and form two rows of alternate spikelets. At maturity, the parts of the spikelets fall away, but the axis of the spike persists. The *spikelet* usually consists of 8—10 flowers (only 6 in fig. 1). Each has a single *glume,* except the terminal spikelet which has two. This glume lies on the outer edge of the spikelet beneath the 2nd flower. It is usually longer than the adjacent pale, half the length of the whole spikelet, and 5—9-ribbed (5-ribbed in fig. 8). The *lower pale* is 5-ribbed, lanceolate, obtuse (rarely acute), and always awnless (figs. 1—5; 8). The *upper pale* has two ciliated keels (figs. 1, 5, 8). The *lodicules* (fig. 8) are ovate-lanceolate, and acute. The *ovary* is glabrous, and the *stigmas* (fig. 1) feathery.

Stamens and stigmas only protrude from the pales, when the grass is in flower. Then, two flowers belonging to a spikelet come into action at the same time (fig. 1). Their stamens and stigmas protrude laterally between the bases of the open pales. The slender filaments are weighed down and bent by the anthers, which now begin to open at the apex. Before dehiscing, the anthers lie at a lower level than the stigmas and self-fertilization is thus rendered impossible. The escaping pollen is transferred (by wind) to lower flowers belonging to other spikelets, and to other plants. The whole arrangement is one to prevent self-fertilization and secure a cross.

At maturity, the spikelet breaks up into *false fruits*, commonly known as *seeds* (figs. 4 and 5). The breaks occur only in the axis of the spikelet, and at the base of each fruit. Each detached joint of the axis remains attached to a fruit, and forms the *stalk* (fig. 5) always lying in front of the upper pale. In this case, the broad, flat stalk, tapering to the base, is very characteristic (distinction from meadow-fescue). The false fruit is composed of a pair of pales enclosing a grain or caryopsis; it is 7 mm. long, and 1—5 mm. broad. The *true* fruit or *caryopsis* (figs. 6 and 7) is acute at the base and rounded at the apex, about one third as long as the upper pale, and yellowish-brown in colour. The ventral surface is concave, the dorsal, convex, with the embryo lying at its base. To see the caryopsis, the pales must be removed from the false fruit.

Varieties.

Varieties. Several varieties of this species are distinguished by botanists, but the points of difference are not constant. Two kinds of seed are found in commerce, viz. common rye-grass *(Lolium perenne)*, and Pacey's rye-grass *(Lolium perenne tenue)*, which is higher in price. Between these, no essential difference exists; the best seeds are sold as Pacey's, the poorer and lighter, as common rye-grass The difference in price, therefore, does not depend upon the variety, but merely on the quality of the seed.

Name.

Name, History, Agricultural value. This plant is variously named rye-grass, perennial rye-grass, and in older writings ray-grass.

History.

For more than 200 years it has been cultivated in England and is thus one of the oldest fodder plants. In 1677 *Dr. Plot* speaks of it as the well known *gramen* »*loliaceum*«. It was first cultivated by *Eustace*, in the county of Oxford. In 1681 it is mentioned by *Worlidge*, who says that it should be preferred to all other fodder grasses, meaning thereby, sainfoin, lucerne, red clover, vetches and refoil. The seed was exported from England to the continent, where it was called »English ray-grass«, a corruption of our rye-grass.

According to *Burger*, English rye-grass was cultivated in upper Italy about the beginning of the present century, and formed the principal grass of the irrigated pastures of Lombardy. By English rye-grass, Burger means the species which is now called Italian, a point frequently overlooked by those authors who refer to Burger's statement.

In Switzerland the cultivation of perennial rye-grass was commenced about the end of last century. In 1761 *Albert Stapfer* of Oberdiessbach, in the canton of Berne, recommended it for cold wet lands with northern exposure; he laid down a number of rules for its cultivation and seed production. On the continent this grass only came into common use about the end of last century.

Agricultural value.

At times over-estimated, at times depreciated, it is yet one of the most valuable grasses. It is more a »bottom« than a »top« grass. For pastures on heavy soils, it cannot be surpassed. In marshy districts, where the soil is good, it forms a large proportion of the herbage, so much so, that in such cases experienced agriculturists use only perennial rye-grass and a little white clover.

Its duration depends very much on the nature of the soil and the climate; on dry, light soils, it disappears after the second year; while in moist climates and on good heavy soils, it will persist for seven years or even longer.

Geographical distribution.

Occurence, climate, soil, manure. Perennial rye-grass is indigenous in *Europe*, throughout the south and centre, to Scandinavia, Southern Lapland, England, Ireland, and Eastern Europe; in *Africa*, Algiers, Madiera; in *Asia*, Caucasus, Georgia; and to the Falkland islands in *America*. It is not indigenous to *North America*, but has been imported from England.

Habitat.

It occurs wild on roadsides on the borders of fields, in meadows and pastures, and on village greens, commons etc.

Limits of altitude.

In Britain it is found at a height of 1150 ft., in the Bavarian Alps at 2500 ft., and in the canton of Glaris, according to *Heer*, at 5000 ft. Along the borders of the St. Gotthard it ascends to 5600 ft.

Climate.

In cold situations it may often suffer from a rigorous winter, although it is not completely destroyed. If the soil is somewhat compact, drought has little effect upon it. This is shown by the fact, that in a dry year, when a mixture of grasses is sown, perennial rye-grass persists in spite of the drought, while other grasses succumb and die. This depends on its habit of forming a compact sward of »bottom« grass. The moist maritime climates of England and the countries round the North Sea, are very suitable for its growth, especially where the soil is of a heavy nature and of good quality.

Soil.

Moist and rich loams and clays are most appropriate. If the supply of moisture and nutriment is adequate, it can also be grown on loamy sands and sandy loams, as well as on marly and calcareous soils. On a rich drained soil, which is not too light, it is a success; but on heaths, dry sands and soils of a scorching type, it does not grow. In general, it requires stiffness as well as moisture in the soil; it can be grown even on the heaviest clays, provided they are drained.

Substances removed from the soil.

According to an old analysis of Wolff*), 1000 lbs. of rye-grass hay remove from the soil: —

Nitrogen . .	18.9 lbs.	Lime . . .	10.6 lbs.
Phosphoric acid .	10.0 „	Magnesia . .	2.4 „
Potash . . .	39.3 „	Sulphuric acid .	6.0 „
Soda . . .	1.3 „	Silica . . .	29.7 „

Manures.

Rye-grasses, whether perennial or Italian, are more benefitted by liquid manure than any other grasses. *Wollny*, for example, obtained the following results per acre: —

Without manure	890 lbs. of hay
With „	2450 „ „ „

The quality of the fodder produced from the manured plots is also improved.

As a top dressing, nitrate of soda is very beneficial. Stevenson found that $1^3/_4$ cwt. per acre might be given with profit.

Irrigation.

Irrigation also acts very beneficially, provided that the land is well drained; if the water at all stagnates, the action is very injurious.

Growth.

Growth, yield, nutritive value. Perennial rye-grass vegetates luxuriantly, forming a complete sward of »bottom grass«, which prevents weeds from springing up. It stands frequent cutting and depasturing. The tread of cattle acts beneficially rather than injuriously, a very good point about a pasture grass.

Development.

According to *Karmrodt's* experiments, the maximum yield is obtained in the year after sowing. The yield per acre was as follows: —

in 1st year	2 cuttings	6050 lbs. hay	
„ 2nd „	3 „	9300 „	
„ 3rd „	3 „	8366 „	
„ 4th „	4 „	5918 „	

The first cutting is always best.

Cutting should take place immediately before flowering, to prevent the hardening of the culms and consequent loss of nutritive value. The plant comes into flower for the first time from the beginning to the middle of June. Flowering is repeated and goes on till late in September, so that a second and a third crop of culms may be obtained.

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*) Dr. Emil Wolff. Aschenanalysen von landwirthschaftlichen Produkten. Berlin 1871.

Yield.

The yield varies much with weather, soil, manure, and mode of cultivation. From a fertile sandy loam, *Pinkert* obtained a yield of 1780 lbs. per acre, while *Kielmann* obtained less than 1600 lbs.

From a fertile loam, *Sinclair* obtained the following yield per acre: —

	Green.	Dry.
On 16th April	4084 lbs.	—
„ flowering	7827 „	3390 lbs.
Aftermath .	3404 „	—

Vianne obtained, from two cuttings taken from a mild rich clay, 5900 lbs. of hay per acre. *Karmrodt* obtained on an average, extending over 4 years, 7300 lbs. *Werner* reckons the average yield at 3900 lbs. per acre. 100 lbs. of grass give 25—42$^1/_2$ lbs. of hay, i. e. on an average, 33$^1/_2$ lbs.

As cut-grass, it yields less than others, while as pasture, it compares more favourably.

Depasturing.

It is essential not to commence depasturing too late in the spring, because as soon as the culms have appared, the produce is not so readily eaten by cattle. The culms are left standing and remain throughout the summer in a withered condition; the value of the pasture is thus much decreased.

Nutritive value.

According to *Wolff* 100 lbs. of hay, contain 79.2 % of organic matter, composed of: —

Albumin	10.2 %	portion assimilated	5.1 %
Fibre	30.2 %	„ „	35.3 %
Non-nitrogenous extractives	36.1 %		
Fat	2.7 %	„ „	0.8 %

Ratio of nitrogenous to non-nitrogenous nutriment 1 : 7.3.

Perennial rye-grass hay is accordingly less nutritive than meadow-hay of medium quality.

Seed-harvesting.

Harvesting, impurities and adulterations of seed. Perennial rye-grass yields abundance of seed, which is easily harvested. The second cutting is used for seed in order to reduce the loss of fodder to a minimum. Cutting should take place before the seeds begin to fall away which they very readily do. It is therefore best to take the crop when the seeds are beginning to assume a leathery consistence, and not to wait until they become brown and hard. They are in right condition about 4 weeks after flowering. The culms are still quite green, the radical leaves beginning to die, and the pales becoming yellowish. At this stage, the grass is cut with a scythe or mower, allowed to lie for one or two days, and turned in the morning before the dew is off; small loose sheaves can also be formed. These are allowed to dry and ripen in rows or stooks. By the first method, the plants are allowed 3 to 4 days in the field; by the second, somewhat longer. They are then led in carts, and treshed out by hand or machine. The seed is frequently obtained merely by shaking and beating with forks or flails; this plan is not economical, since more or less of the seed remains in the hay, and is lost. If the seed is very ripe, it is advisable to beat it out on the field, on cloths spread to receive it. It should be at once cleaned by the winnower, and spread out in a thin layer. Wen laid out in heaps, the temperature rises, and the germinating power of the seed is considerably diminished.

Yield of Seed.

Sprengel states that over 530 lbs. of seed can be obtained per acre. From a stiff sandy loam *Pinkert* took 700 lbs.; others obtained amounts varying from 880—1050 lbs. In Hohenheim, 350 lbs. of seed were obtained from a poor soil; from well manured land 700 lbs. *Werner* gives an average of 260—350 lbs. of seed, and 2000—2800 lbs. of hay per acre.

Commercial seed.

Commercial seed is usually obtained from Scotland and England, where rye-grass is extensivly cultivated. Glasgow and London merchants buy the seed, reclean and assort it. The cleanings consist, in the main, of Yorkshire fog *(Holcus lanatus, L.)*, soft brome *(Bromus mollis, L.)*, and *Festuca bromoides, L.* The seed is assorted according to weight per bushel, purity, and germinating power. A Glasgow firm for example, offered four qualities of perennial rye-grass which on analysis gave the following results:

	I. quality.	II. quality.	III. quality.	IV. quality.
Purity	96.9 %	91.1 %	82.6 %	32.5 %
Germination	73 „	53 „	34 „	10 „
Pure and germinating seed	70.7 „	48.3 „	28.1 „	3.3 „
Price per cwt. shillings	22/-	20/-	12/6	7/6
Price of pure and germinating seed per cwt.	31/-	41/6	44/6	227/-

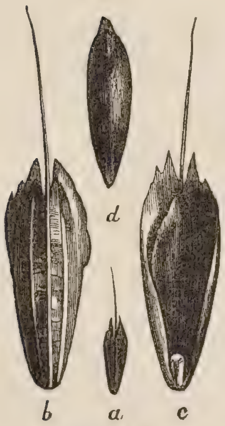

Fig. 13.
Soft brome.
Bromus mollis L.
a. False fruit, natural size;
b. Same enlarged, seen from the dorsal surface.
c. Same enlarged, seen from the ventral surface.
d. Caryopsis enlarged (after Nobbe).

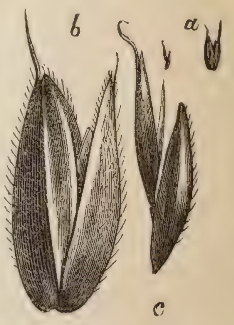

Fig. 14.
Yorkshire fog.
Holcus lanatus, L.
a. False-fruit (spikelets), natural size.
b. The same, enlarged.
c. The spikelet without the glumes, (after Nobbe).

A comparison of the prices of pure and germinating seed in these samples shows that quality IV is more than 7 times as dear as quality I, although the cost of the commercial seed is only one third.

Since the best qualities have usually the heaviest weight per bushel, this is usually taken as a gauge of the value. For example 30 lb., 28 lb. and 24 lb. rye-grasses are spoken of; this means that a bushel weighs 30, 28 or 24 lbs.

Impurities.

As already mentioned soft brome (fig. 13.) Yorkshire fog (fig. 14) and *Festuca bromoides* are frequent impurities. Ribgrass *(Plantago lanceolata,* L.), buttercups *(Ranunculus acris* and *repens)*, sorrel *(Rumex acetosella,* L.), and similar weeds, are also very common.

Adulterations.

This seed is very rarely adulterated because it is so cheap. At times soft brome is sold as *Lolium perenne* but this fraud is very readily detected, as the seed of the brome is quite different from that of the rye-grass; on the other hand, perennial rye-grass is often mixed with dearer grass seeds, and more especially with meadow-fescue. This fraud is readily detected when a sample of the seed is examined by an ordinary lens. The »stalk« of the rye-grass is quite flat, broad at the top, and narrow at the base (see fig. 5).

Seed-quality.

Seed and amounts to be sown. Analyses of more than 250 samples of seeds of this grass show an average purity of 94 %, and a germination of 70 %. Good commercial seed should have 95 % purity and 75 % germination. 1 lb. of pure seed contains, on an average, 336,800 grains; larger and heavier seed contains only 182,000, while some commercial samples contain about half a million grains. For sowing, heavy seed should of course be preferred. The weight per bushel is as variable as the number of seeds per lb. The heaviest seed weighs about 30 lbs. per bushel, while poorer qualities weigh scarcely half as much.

Amounts to be sown.

One acre of ground requires 55 lbs. of seed containing 71 % pure and germinating = 38½ lbs. of pure and germinating seed.

Mixtures.

For agricultural purposes perennial rye-grass is rarely sown alone. As already pointed out, it may occupy about 80 % of a mixture with white clover. Such a mixture forms the excellent pastures on the alluvial lands of Northern Germany. If for mowing, much lower percentages should be used, especially when the soil is stiff. About 20 % may be used for mixing with clovers to form »clover-grass«. For temporary grass-meadows the amount should not exceed 10 %: if permanence is important, 5 % should rarely be exceeded. On a good soil, it should never be entirely absent from any mixture because of its rapid and dense growth.

Formation of lawns.

In England, perennial rye-grass is frequently used for forming lawns. To make the turf as compact as possible, seed of the best quality should be selected, and twice the normal amount sown. Yorkshire fog, or soft-brome grass, when present, forms cushion-like tufts which deface the lawn. Frequent mowing is necessary, and, the lawn should be broken up and resown every 2 or 3 years.

II. Italian rye-grass.

Lolium Italicum, Alex. Br. *(L. multiflorum*, Lmk.*)*

Explanation of plate.

Fig. A. Entire plant in flower, shewing two spikes.
,, 1. Spikelet in flower with a portion of the axis of the spike.
,, 2. The same, before flowering.
,, 3. Flower and upper pale, shewing the 2 lodicules, 3 stamens, and pistil.
,, 4. The pales from the dorsal surface shewing the lower.
,, 5. The pales, from the ventral surface, shewing the upper.
,, 6. False fruit (seed), dorsal surface.
,, 7. False fruit, ventral surface, shewing the stalk.
,, 8. Caryopsis, dorsal surface.
,, 9. Caryopsis, ventral surface.
,, 10. Transverse section of a young leaf, shewing the rolled vernation and the ribs (after Lund).
,, 11. The short, obtuse ligule.

Botanical description.

Botanical description. In warm climates, Italian rye-grass tends to become an annual, but with us it usually lasts two years or longer. It forms compact, compound tufts of grass. The *stolons* are shorter, stouter, and more erect (fig. A)*) than those of perennial rye-grass, hence the greater compactness of the whole tuft. The *branches* are intravaginal. The *sheaths* of the radical leaves are red between the veins. The *culms* are ascending, reach a height of 1—3 ft., and are upwards rough. The *leaf-blades* differ from those of perennial rye-grass in the following respects: — the colour is lighter, the under surface is shining, and, in the bud, they are rolled (fig. 10). A field of Italian rye-grass can readily be known in the distance by the shining appearance of the leaves when they are shaken by the wind. Further the leaves of Italian rye-grass are usually somewhat broader and softer. The upper surfaces are similarly rough and ribbed. The *ligule* is quite like that of perennial rye-grass (fig. 11). The *spike* (fig. A) is composed of numerous spikelets (up to 28), and is thus longer than that of *Lolium perenne*, often over 1 ft. The arrangement and direction of the spikelets are identical in the two grasses. The same is the case with the *glumes* i. e. the lower is absent; if growth is very luxuriant, the lower glume may make its appearance as a cleft rudiment next the axis of the spike. This is also the case with the darnel *(Lolium temu-*

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*) *Lolium Boucheanum*, Kunth, and *Lolium multiflorum*, Gaudin. (Flora helvetica p. 354) are such annual varieties.

lentum). Each *spikelet* (figs. 1 and 2) is composed of from 9 to 20 flowers, rarely 3 — 5. The *upper glume* which alone is present, is 7-ribbed, shorter or as long as the lower pale, usually less than half the whole spikelet. The *lower pale* (figs. 1, 2, 4—7) is 5-ribbed, with a long terminal awn, which may be undeveloped on the lowest flowers of the spikelet (see below, variety *muticum*). The *upper pale* (figs. 1, 2, 3, 5, 7) has two ciliated keels. The *lodicules, stamens*, and *pistil* are identical with those of *L. perenne.* When the spike is ripe, its axis readily breaks into pieces (distinction from *L. perenne*). The spikelets themselves break up to form false fruits (seeds) as in perennial rye-grass. The caryopsis together with the pales and the stalk form the *false fruit* (figs. 6, 7); its length, including the awn, is about 13 mm. The caryopsis resembles that of *Lolium perenne* but is longer.

Varieties.

Varieties. The normal type of the species is the awned form; at times, however, varieties with awnless pales appear *(Lolium muticum* D. C.). This awnless variety is readily distinguished from perennial rye-grass, by the convolute (rolled) vernation of its leaves. Both varieties are of equal value to the farmer.

Name and history.

The cultivation of this grass probably commenced in *Lombardy;* thence it spread into the other countries of Europe. Because of this, *Braun* in 1834 named it *Lolium Italicum.* Formerly it was regarded as an awned variety of perennial rye-grass and was called *Lolium perenne aristatum. Burger* in his writings on Italian agriculture (1830 and 1851) speaks of the grass, which abounds in the irrigated pastures of Lombardy, as perennial rye-grass: this has given rise to much confusion and error, as the grass there is really Italian rye-grass. It is not mentioned either by *Sinclair* (1825) or *Schwerz* (1837); perennial rye-grass is alone referred to. At the beginning of the present century, *Fellenberg* obtained seed from Italy and cultivated the grass at Hofwyl. In 1818 *André Thouin* cultivated it in France, and *Matthieu de Dombasle* extended its cultivation there; he obtained his seed from *Fellenberg.* About 1840, *Lawson* introduced it into Scotland, and soon after it became known in England. *Wm. Dickinson* grew it, about this time, at Willesden, and thanks to him, it soon became widely known. He obtained remarkably large yields by means of sewage irrigation. His success soon became known throughout England and Scotland, and now, in this country, Italian rye-grass is of more importance than in Lombardy itself.

Agricultural value.

This is one of the best grasses for mowing, since it surpasses all others in rapidity of growth, and, in forced cultivation, gives the highest yield. Its duration is, however, short: in Scotland it is often used only for a single year, but in general it lasts 2 years.

Geographical distribution.

Occurrence, climate, soil, manure. Italian rye-grass is indigenous to: — Spain, France, Germany, Belgium, Switzerland, Italy, Dalmatia, Croatia, Turkey and Greece. It is not indigenous to N. America. It is especially frequent in the grass lands of Lombardy. At present it is extensively cultivated throughout the whole European continent, Great Britain, Denmark, southern Scandinavia, etc. In England and Scotland it is frequently found in a half naturalised state. In Ireland, too, it is often seen in fields and waste places, but only as an escape from cultivation.

Habitat.

It occurs wild wherever manure has accumulated, as on the margins of ditches, roadsides, etc.

Limits of altitude.

In Upper Engadine it has been cultivated at a height of 5,600 ft. (Bevers), and at Flims ascends to 3,600 ft.

Climate.

Although of southern origin, it is an error to suppose that this grass cannot withstand the winters of Central and Northern Europe. Long experience has shown, that our climates are not too extreme. Winter cold is only dangerous on loose soil; any evil effects can be avoided by rolling, or by covering with fresh farm yard manure, in autumn. As with all other grasses, so here, rolling in spring should never be omitted. It is true, that this grass succeeds best in countries adapted for vine culture, provided that the soil is suitable, still, in colder countries such as Scotland, excellent crops of Italian rye-grass are obtained. It resists drought very well, especially, if the soil is deep.

It succeeds best on warm, moist soils,
moist loamy sands, or on good calcareous loa
to great perfection, and gives splendid produ
also thrives very well, if the subsoil is por
the produce is smaller. On poor sand, or a
Sprengel *) states that it can be cultivated on h
berally supplied with farmyard manure.

1000 lbs. of Italian rye-grass hay remove

Nitrogen . .	20.8 lbs.
Phosphoric acid .	3.8 ,,
Potash . . .	7.5 ,,
Soda . . .	3.1 ,,

According to *Karmrodt's* experiments, Ita
and more nitrogen, than perennial rye-grass.

No other grass repays manuring so well
fitable. *Dickinson* obtained 8 or 9 crops of h
with a clayey subsoil. The total yield was 2
The average produce of 7 cuttings was 154
Dickinson reckoned the nutritive value as equ
liquid manures, other agriculturists more esp
vellous produce.**)

The liquid manure is led by a set of pipes, fr
fermentation goes on. Before using, it is diluted
tanks are generally used; the one receives the fresh
From these tanks, iron pipes, laid at a depth of 2
pipes are arranged so that every part of the field n
hydrants are set up. Hose connected with these
driven through the tubes either by its own hydrost
gements are very costly, they give good results. Aft
liquid are distributed to each acre. Often, however,
ures; these are washed into the soil by the liquid.
such as Chili saltpetre, bone-meal, or sulphate of a

At Hofwyl, *Fellenberg*, without the undergroun
ordinary way, took 8 mowings. The liquid used sh
obtained by frequent distribution of very dilute liqui

On a light soil with a warm exposure, I
tion; this is well exemplified in the case of t
70% of the whole herbage is Italian rye-grass
be mown 5, 6, or even 8 times in a year.
studied in the neighbourhood of Milan: — th
almost perfect: the soil is a loam, rich in hu
the climate also adds to the fertility.

oil.

nure.

gation.

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*) Dr Karl Sprengel. Meine Erfahrungen im Gebiete
Leipzig 1850.

**) Dr. Eduard Hartstein. Die flüssige Düngung und
culture« in Encyclopædia Britannica, ninth edition.

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necessary data are:—

1. The purity and germination of the seeds to be used. This information is given by the seedsman, or the matter can be tested by the consulting botanists of the various Agricultural Societies. 2. The amount of pure and germinating seed necessary to cover an acre with each kind of grass or clover; on which head complete information is given in Table I. of the Appendix to Stebler's *Best Forage Plants* (London: Nutt).

The method can be explained in the fewest words. Suppose an acre is to be laid down to permanent grass. The most suitable plants are first selected. To each is assigned a percentage indicating the proportion of the acre which it is desirable that it should cover. This done, any school-boy can finish; for all that remains is to calculate the amounts of seed corresponding to the percentages to be covered. Take perennial rye-grass as an example, and suppose 10 per cent. assigned to it. Turning to Stebler's tables, you find that 58 lbs. of pure and germinating seed are wanted per acre of rye-grass, and you perceive that to cover 10 per cent. requires, therefore, 5·8 lbs. But the quality of rye-grass seed at disposal is (say) 71 per cent., which means that only 71 per cent. of the seed to be actually used is pure and germinating. 8·1 lbs. of seed of this quality represent 5·8 lbs. which is pure and germinating. Accordingly, to cover 10 per cent. with rye-grass requires 8·1 lbs. of seed whose quality is 71 per cent.; the calculation for this species is now complete; and nothing remains but to determine the amounts of the other constituents in exactly the same way.

These calculations, paltry as they are, can be reduced to the proportions of a sum in simple division, if a similar table to No. II. in the Appendix to Stebler is used. It would be advisable for seedsmen and Farmers' Supply Associations to provide a table of the kind indicated, and calculated for the special qualities of seed which they have on sale. To show how useful this would be, there follows here a complete example of Stebler's method of construction calculated from his second table:

PERMANENT MIXTURE FOR A MEDIUM SOIL.
Additional Seed=50 per Cent.

	NAME OF SPECIES.	Percentage of Ground to be Covered.	Quality of Seed.	Amount of Seed.
			Per Cent.	Lbs.
	Red clover, . . .	5	88	1¼
	Alsike clover, . . .	5	73	1
	White clover, . .	10	74	1½
Permanent Grasses.	Meadow fescue, . .	13	71	10
	Cocksfoot, . . .	10	53	5¼
	Meadow foxtail, . .	8	27	2¾
	Smooth-stalked meadow grass, . . .	10	48	2½
	Rough-stalked meadow grass, ...	4	45	1¼
	Golden oat-grass, . .	4	16	1¾
	Crested dogstail, . .	4	54	1½
	Timothy, . . .	13	87	3¼
	False oat-grass, . .	2	49	2
	Italian rye-grass, . .	2	67	1½
	Perennial rye-grass, .	10	71	8
		100		43½

experience, he is the proper person to compound grass seeds; but this is a huge mistake. It is enough that he provides good seeds; it is the farmer's business to see that his purchases are properly used, and that adequate and suitable produce is obtained from them. Incredible as it may seem, the mixtures described above are still in the field; they are formulated by lecturers to students of agricultural science; they teem in seed catalogues, and in recent agricultural literature as well. In fact, the farmer is commonly acquainted with no other kind.

It is small wonder that the result is failure and disaster, and none that so many sensible farmers have come to the conclusion that for good grass they must trust to Providence; and it were well for them to begin to try and realise that Providence is incapable of turning out a tract of grass-land at all equal to that which is to be secured by the use of a proper artificial combination of seeds. Why these absurd impostures are popular is soon disclosed to the inquiring mind; and the reason, if properly understood, will suffice to give a fair idea of the whole question. The mixtures in point are formulated as pounds of various seeds, in a tongue unknown to most of us, however agricultural we may be. Before any conception can be formed either of the real meaning of the mixture or of the result to be expected from it, the formula requires to be translated and expressed in terms of the corresponding plants, so as to show how many of each kind there are (as in Sinclair's method), or preferably (because simpler and more practical) the amount of ground covered by each species. This found, the result to be expected from any given combination is known beforehand: the mixture has a right to be regarded as rational and scientific; indeed the ability to predict is the characteristic of all true scientific method. In the class of compound here referred to, it is quite impossible to translate the formula in this way, as the germinating power of the seeds is not given. Only one way remains of proving the value, and that is by actual sowing in the field, and allowing the mixture to occupy the land for an indefinite number of years. The farmer will then have experience—bitter, indeed, it may be—and the seedsman the money paid for the seeds. Experience gained at this expense is worth very little after all; for the farmer has no chance of finding in what respects the seeds used were defective, as the resulting plants are so intermingled that it is well nigh impossible to come to any conclusion regarding the proportion of the various species.

To Mr. James Hunter of Chester, more than to any one else in Britain, is due the credit of bringing us back to the rational basis laid down at the beginning of this century. He saw quite clearly those points in which the fashionable mixtures were defective, and set himself to find a remedy. Following in the footsteps of Sinclair, he made numerous experiments, and reasoned out the number of germinating seeds proper for each grass and clover constituent. More than that, he paid particular attention to purity and germination, in order to have very complete data at command, and was thus able to advance greatly the position first assumed by Sinclair. It was plain that mixtures formulated on such principles could not escape being good; and practical experience only confirms this view. Hunter's works on the subject will repay careful study, and must always be consulted by those interested in such questions, but his

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It succeeds best on warm, moist soils, more especially on marls rich in humus, on moist loamy sands, or on good calcareous loams. A stiff soil is best; on such it comes to great perfection, and gives splendid produce. On clay, containing humus or lime, it also thrives very well, if the subsoil is porous; on heavy clay, it is less certain, and the produce is smaller. On poor sand, or any very dry soil, it does not thrive well. *Sprengel**) states that it can be cultivated on heath land which has ben well marled and liberally supplied with farmyard manure.

1000 lbs. of Italian rye-grass hay remove from the soil: —

Nitrogen . .	20.8 lbs.	Lime . . .	6.0 lbs.
Phosphoric acid .	3.8 ,,	Magnesia . .	1.3 ,,
Potash . . .	7.5 ,,	Sulphuric acid .	1.7 ,,
Soda . . .	3.1 ,,	Silica . . .	35.5 ,,

According to *Karmrodt's* experiments, Italian rye-grass requires less mineral matter, and more nitrogen, than perennial rye-grass.

Manure.

No other grass repays manuring so well as this; on sewage-farms it is especially profitable. *Dickinson* obtained 8 or 9 crops of hay in a year from a well drained clay soil with a clayey subsoil. The total yield was 224,400 lbs. of grass, and 44,000 lbs. of hay. The average produce of 7 cuttings was 154,000 lbs. of grass, and 30,800 lbs. of hay. Dickinson reckoned the nutritive value as equivalent to that of the best clover. By using liquid manures, other agriculturists more especially in Scotland, have also obtained marvellous produce.**)

The liquid manure is led by a set of pipes, from the stables and cattle-stalls, to a reservoir where fermentation goes on. Before using, it is diluted with two or three times its bulk of water. Two tanks are generally used; the one receives the fresh urine, while fermentation is going on in the other. From these tanks, iron pipes, laid at a depth of 2 to 2½ ft., convey the liquid to the field; the pipes are arranged so that every part of the field may be supplied from them. At appropriate points hydrants are set up. Hose connected with these spread the liquid over the surface. The fluid is driven through the tubes either by its own hydrostatic pressure, or by pumps. Although such arrangements are very costly, they give good results. After each cutting, 5,000 to 7,500 gallons of the dilute liquid are distributed to each acre. Often, however, the ground is first spread with guano, or other manures; these are washed into the soil by the liquid. With guano at its present high price, other manures, such as Chili saltpetre, bone-meal, or sulphate of ammonia should be used either separately or mixed.

At Hofwyl, *Fellenberg*, without the underground tubes, merely using the liquid manure in the ordinary way, took 8 mowings. The liquid used should not be too concentrated; the best results are obtained by frequent distribution of very dilute liquid.

Irrigation.

On a light soil with a warm exposure, Italian rye-grass is much benefitted by irrigation; this is well exemplified in the case of the irrigated grass-lands of Lombardy, where 70% of the whole herbage is Italian rye-grass. These grass-land called »Marcita«, can be be mown 5, 6, or even 8 times in a year. The process of irrigation can be very readily studied in the neighbourhood of Milan: — there, the conditions suitable for irrigation are almost perfect: the soil is a loam, rich in humus, permeable and warm. The mildness of the climate also adds to the fertility.

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*) Dr Karl Sprengel. Meine Erfahrungen im Gebiete der allgemeinen und speziellen Pflanzenkultur. Zweiter Band. Leipzig 1850.

**) Dr. Eduard Hartstein. Die flüssige Düngung und das italienische Raygras. Bonn 1859. See also article »Agriculture« in Encyclopædia Britannica, ninth edition.

Growth.

Growth. Yield. Nutritive value. Italian rye-grass forms compact tufts of leaves. Frequent rolling is necessary to keep the grass uniform.

Development.

From the time of sowing, no other grass grows and developes so rapidly as this. *Fulton* states that in England he has seen it grow as much as 2 inches in a day after an application of liquid manure. On irrigated meadows it often attains a height of 16—20 inches 3 weeks after mowing. *Dickinson*, in a favourable season, could obtain a good cutting every 3—6 weeks. It may be sown either in spring or in autumn, in the former case, the yield is at its maximum the same year, in the latter, the next year.

Karmrodt obtained the following produce per acre: —

1st year .	8188 lbs. of hay,
2nd ,, .	8188 ,, ,,
3rd ,, .	7120 ,, ,,
4th ,, .	7296 ,, ,,

The produce usually becomes scant in the third year, it is therefore advisable to break up the grass after a two years ley.

It begins to shoot early in the spring and continues growing late in autumn. In Lombardy and in England, it may be cut from March to autumn, often as late as December. It comes into flower, for the first time, about the end of May, or the beginning of June, and produces after-math till autumn. The first cutting is usually most productive, but the others are very little less. It should always be cut before flowering, because at that period, the culms become hard, losing thereby flavour and nutritive value.

Yield.

The yield is exceedingly variable.

By the use of liquid manure *Lord Essex* obtained 17,600 lbs. of hay per acre; the *Marquis of Ailsa* 17,600—22,000 lbs.; *Finnie* 7,260 lbs.; *Ralston* 33,800 lbs.; *Telfer* 30,800—39,600 lbs.; *Neilson* 22,800—28,160 lbs. and *Dickinson* on an average 30,800 lbs. On the continent, the yields are usually lower, *Pinkert & Rathusius* obtained 26,400 lbs. of hay per acre; *Karmrodt* 5,630 lbs.; Pastor *Thieme* 9,590 lbs., and *Stecher* 13,290 lbs. In France *Vianne* reports in various experiments, 28,600 lbs. of hay per acre. Large produce can only be obtained by copious manuring, more especially with liquid manures, but, on an unfavorable soil, the produce is always poor.

Nutritive value.

The nutritive value is superior to that of perennial rye-grass, as is shown by the composition. According to Wolff 100 lbs. of hay contain: —

Organic matter	77.9 %		
composed of:			
Abumin (Nitrogen × 6.25) . .	11.2 %	portion assimilated	7.1 %
Fibre	22.9 ,,	,, ,,	41.5 ,,
Non-nitrogenous extractives . .	40.6 ,,		
Fat.	3.2 ,,	,, ,,	1.4 ,,

Ratio of nitrogenous to non-nitrogenous nutriment 1 : 6.3

Seed harvest.

Harvesting, impurities and adulteration of seed. Like perennial rye-grass, Italian yields a large quantity of seed which is easily harvested, and hence very profitable to the grower. The seed is taken from the second cutting; in Scotland, often from the first. In a warm summer, two crops of seed may be obtained from the same field. Seed from the first cutting has usually low germinating power, especially if frost has come on about the time of flowering or somewhat later. When two crops are taken, better seed is obtained from the second. The remarks regarding ripeness, harvesting, and threshing, of perennial rye-grass apply equally to Italian. It should, however, be observed that the seed of Italian rye-grass detaches much more readily, as the axis of the spikelet is more brittle: — if this be not attended to, a large proportion of the seed may fall off, and the total amount obtained may thus be very largely diminished. To obtain seed, it is not necessary to sow Italian rye-grass by itself; it can be grown in mixture with red clover: from such a mixture, Italian rye-grass seed is very readily separated.

Yield of seed.

From Italian rye-grass grown in rows *Pinkert* obtained 700—880 lbs. of seed per acre and, as accessory product, 600 lbs. in the third year, *Sprengel* states that the yield is equal to that of perennial rye-grass. *Werner* gives the average yield of seed as 300—400 lbs. per acre.

Impurities.

The impurities noticed under perennial rye-grass may also occur here, viz. buttercups *(Ranunculus acris* and *repens),* rib-grass *(Plantago lanceolata,* L.), sorrel *(Rumex acetosella,* L.), *Festuca bromoides,* soft brome *(Bromus mollis,* L.), small yellow clover *(Trifolium filiforme),* etc.

Adulteration.

Adulteration is rare, because of the cheapness of the seed. Under the name of »Scotch rye-grass«, mixtures of perennial and Italian are at times brought into commerce. In such cases, about one half of the seed is awned (Italian), and the other half awnless (perennial).

Seed quality.

Seed and Amounts to be sown. The average purity of commercial seed is 94 %, and the average germinating power 59 %. Good seed ought, in general, to have 95 % purity, and 70 % germinating power. If the seed has been kept, the germination rapidly diminishes. 1 lb. of pure seed contains, on an average, 285,000 grains. The mean weight of good seed per bushel is 16 lbs., in the finest qualities 24 lbs.; in commerce, seed scarcely half this weight per bushel, consisting in the main of empty pales, is often met with. The weight per bushel is usually stated, and gives a somewhat rough idea of the quality, e. g.

New seed of Italian rye-grass	14 lbs.	16 lbs.	18 lbs.	20 lbs. per bushel
Price per cwt. . . .	21 s. 6 d.	22 s. 6 d.	24 s. 6 d.	26 s. 6 d.

Seed from Italy is usually very impure, and inferior in quality to Scotch seed.

Quantity to be sown.
Sowing.

One acre requires 48½ lbs. of seed containing 67% pure and germinating = 32.4 lbs. of pure and germinating seed. The commercial price of good seed is about 4d. per pound; the cost per acre for a pure sowing is accordingly 16/- to 17/-. Italian rye-grass is often sown pure for a two-years ley, and then, by forced culture, gives a very high yield. In England it is the custom to add about 10 lbs. of red clover. Italian rye-grass is also recommended as a protective crop for mixtures; in that case, an extra amount of Italian seed, 10—20 lbs. over the ordinary quantity, is used. This practice cannot be too strongly condemned, because Italian rye-grass becomes so luxuriant in the first and second years, that the other grasses are suppressed. In the third year, when the Italian rye-grass has disappeared, the grasses sown along with it are also gone, and the ground requires to be broken up. This property of starving out, and overshadowing plants mixed with it, renders it useful for the destruction of field horse-tail *(Equisetum arvense),* and other weeds with creeping rhizomes. On the advice of *Vilmorin,* a piece of ground completely covered with field horse-tail, was sown with Italian rye-grass in 1853. In the following year, the horse-tail was considerably diminished, and in 1855, had quite disappeared *(Pinkert).*

Mixtures.

For a similar reason, Italian rye-grass ought not to occupy more than 5 % of a mixture for permanent or temporary meadows. No mixture with more than 10 % ought to be used. A mixture of Italian rye-grass with Carnation clover may be sown in August, on a light warm soil, and in the following May a very good crop should be obtained. The ground is at once ploughed up, since carnation clover, cut at the time of flowering, gives no aftermath. Generally it is used with other clovers to form «clover-grass». Where red clover by itself is not a certain crop, a mixture with Italian rye-grass may succeed very well. On stiff medium soils about 10 % of Italian rye-grass mixed with 90 % of red clover may be used. As the soil becomes poorer, the percentage of rye-grass is increased so as to cover 50 % of the whole ground. In a mixture with clover, Italian rye-grass has this disadvantage; it grows quicker, and becomes hard before the growth of the clover has commenced. For this reason, farmers now use a smaller proportion of Italian rye-grass and add other grasses such as timothy, cocksfoot, etc., which for permanence are far preferable.

Its rapid growth allows Italian rye-grass to be used for filling gaps in clover, lucerne, and sainfoin fields. For this purpose, the ground is harrowed, the seed sown, and the field rolled.

Time of sowing.

Used by itself, Italian rye-grass is sown in August or September. This is also the best time, where the winter is not too severe, and where no protective crop is used; but with a cereal as a protective crop, spring-sowing is best. The seed is sown along with spring wheat; with winter wheat, it is sown in April, and never earlier than the end of March. Attempts have been made to sow it in autumn along with winter wheat, but, in that case, it grows faster than the wheat, and the produce of the cereal crop is much diminished.

III. Rough Cocksfoot.

Dactylis glomerata L.

Explanation of plate.

Fig. A. Entire plant in flower, shewing the simple tuft of grass and two inflorescences.
,, 1. Spikelet in flower, side-view.
,, 2. Flower with its two pales, detached from a spikelet.
,, 3. The same, with the lower pale removed; shewing 2 lodicules, 3 stamens, the pistil, and the upper pale.
,, 4. A pair of false fruits seen from the side.
,, 5. The same, seen from the dorsal surface of the upper false-fruit, shewing the bend at the apex.
,, 6. A false fruit, ventral surface, shewing the stalk.
,, 7. Caryopsis, ventral surface.
,, 8. Caryopsis, dorsal surface, shewing the embryo.
,, 9. Diagram of the spikelet, shewing three flowers with their pales and a rudiment.
,, 10. The ligule.
,, 11. Transverse section of a young shoot, shewing 2 entire sheaths, and 2 folded blades.
,, 12. Transverse section of the leaf-blade.

Botanical description.

Cocksfoot forms a simple compact tuft of grass. The tuft is not deeply seated in the ground, but stand out like a cushion; and hence the grass is easily uprooted, when depastured. No stolons are produced. The *leafy branches* are all intravaginal and ascend somewhat obliquely. They are strong, vigorous, and flattened at the sides. The *sheaths* of the old radical leaves are brown and persistent; within these the younger shoots have a fan-like arrangement (fig. A). The *culms* are strong and smooth; from 18 inches to 3 ft. high. The *leaves* are folded in the bud, and the young shoots thus appear laterally compressed and two-edged (fig. 11). The *sheath* is complete (best seen in a section through the upper part of a young shoot fig. 11), and rough from above downwards. The growth and expansion of the culm, bursts the sheaths which surround it, and thus the sheaths of the culm-leaves are usually split. The *leaf-blades* are long, rough, and strongly keeled; the ribs are very inconspicuous (fig. 12). The *ligule* is long and more or less torn at the apex (fig. 10). The *inflorescence* is a one-sided panicle, composed of numerous spikelets, which form dense tufts at the ends of the thick, stiff, rough branches (fig. A). Each *spikelet* contains 3 to 4 flowers, and is laterally compressed. The *glumes* are slightly shorter than the pales of the lowest flowers, keeled, and acuminate; the lower has 1 to 3 nerves, and a glabrous keel (figs. 1 and 9); the upper, 3 to 5 nerves, and a ciliated keel (figs. 1 and 9). The *pales* are of two kinds, the lower (figs. 1, 2, 4, 5, 9), has 5 nerves, a short apical awn, rough hairs on the keel, and the surface often somewhat downy; the upper (figs. 1, 3, 6 and 9) has two finely ciliated keels prolonged into a pair of apical teeth, and its outer surface is concave. The *flower* is composed of two, short, ovate lodicules, 3 stamens, and a pistil with a long, glabrous ovary (fig. 3).

When ripe, the glumes do not detach, but the fruits readily fall away. The false fruit (the caryopsis enclosed in the lower and upper pales) is 5—6 mm. long without the awn, 8—9 mm. with it, strongly compressed at the sides, and bent at the apex towards the broadside of the spikelet (figs. 4, 5 and 6). The fruits either separate from one another or may remain united in pairs (fig. 4). The *stalk* (a detached portion of the axis of the spikelet), is strong, and becomes broad and flat towards the apex (fig. 6); it springs from the base of the upper pale. The *caryopsis*, which lies free between the pales, is ovate in form, and slightly concave on the ventral surface (figs. 7 and 8). The *embryo* is very minute (fig. 8).

Name.

The English name of this grass refers to the form of the panicle, the tufts of spikelets are often in groups roughly resembling a cock's foot. As it is frequent under the shade of orchard-trees in America, it is there usually spoken of as »*orchard-grass*«.

History.

In Switzerland cocksfoot was first cultivated by *Fellenberg*. A Swiss commission says, that in 1808, 9 acres were sown with the seed of this grass obtained from the lands of Hofwyl. The importation of seed from Dauphiny commenced about 1860. In England, *Coke* cultivated it on a large scale in Norfolk, about the beginning of the present century.

Agricultural value.

Schwerz regards it as one of the best grasses. It is a quick-growing, tolerably early »top-grass«, with tall culms, and long, thick, succulent leaves. When grown in a deep rich soil the leaves develope luxuriantly, especially in the second cutting, often attaining a length of 2 ft. or more. This excessive leaf-development enables it to grow well in the shade, or beneath trees. For pasture, it is not so good as for mowing because, it produces compact cushions of grass, which are easily pulled out of the ground by browsing cattle.

Geographical distribution.

Occurrence, climate, soil, manure. Cocksfoot is indigenous — to *Europe*, except Lapland and Arctic Russia; to *Africa*, in Algeria, the Canaries and Madeira; to *Asia*, in Caucasus, the desert of Sinai and Siberia. It has been introduced into North America. Occurs throughout England, Scotland and Ireland, from Cornwall, Isle of Wight and Kent to Shetland, Orkney and the Hebrides. It descends in the south to the coast-level and ascends to 1400 feet in the county of Aberdeen.

Habitat.

This grass is very common in rich meadows and pastures, and on the borders of woods, fields, and also on roadsides.

Limits of altitude.

On the Alps, it ascends to 6500 ft. (De Candolle, Heer); in Spain, to 9,800 ft. (Boissier).

Climate.

Cocksfoot is little affected by drought, when the soil is sufficiently deep to allow the much-branched system of roots to descend into it. *Sprengel* has shewn that the roots can descend to a depth of two or more feet. During a period of drought depasturing does greatest damage, because then the plants are most easily uprooted. Late frosts cause serious injury, but the cold of winter affects it very little.

Soil.

This grass succeeds on almost any kind of soil, except poor sands and heaths. Fullest development is attained on loams and clays, which are rich, deep, and moist; on marly loams and clays; and indeed, on any good soil, which is rich in humus. It also grows on the better kinds of sands, or on calcareous soils, provided that there is a sufficiency of moisture; in such cases the yield is, however, much diminished. In general, it thrives better on moist, stiff soils; than on those of a dry and light type. It can be grown with profit on heavy cold clays.

Substances removed from the soil.

According to Wolff 1000 lbs. of hay remove from the soil: —

Nitrogen	18.3 lbs.	Magnesia	1.5 lbs.
Phosphoric Acid . .	3.7 ,,	Lime	3.1 ,,
Potash	16.8 ,,	Sulphuric Acid . .	1.3 ,,
Soda	2.2 ,,	Silica	16.8 ,,

Manures.

Cocksfoot thrives on well-manured land, and, if appropriate mixtures are used, manuring is richly repaid. It can with advantage be used on irrigated ground; then, the grass becomes tall and luxuriant, attaining a height of 3 ft. or more.

Growth.

Growth, Yield, Nutritive value. Cocksfoot vegetates luxuriantly; the grass which it produces forms simple, compact tufts which stand well out of the ground, forming cushions of grass; when sown by itself, therefore, it does not form a complete sward, and the whole grass is cushion-like and unequal. In the first year after sowing, the development is moderate, the produce consists mainly of leaves with a few culms; in the second year, a full yield is obtained. Growth commences early in spring, and by the end of May or the beginning of June, the grass is in flower. If possible it should be cut before flowering, because the culms then become hard, and are not so readily eaten. Since cocksfoot forms one of the main constituents of the hay grown in Switzerland, farmers there say that hay should be made when cocksfoot is coming into flower. Another Swiss proverb is, that »Cocksfoot grows under the scythe«. Its herbage, which springs up so quickly after cutting, is at first, of a pale green colour. This, and the rapidity of its growth, distinguish it at once from other grasses growing with it. After each mowing the number of culms which are produced diminishes, while the amount of leaf increases. The leaves form excellent fodder and may be used either green or dry. Of all grasses, this probably yields the most nutritive aftermath.

Development.

Harvest.

Yield.

Sinclair obtained, from a rich sandy loam, the following produce per acre: —

	Green.	Dry.
15th April	10,209 lbs.	—
At time of flowering .	27,905 ,,	11,859 lbs.
Aftermath	11,910 ,,	—

Pinkert obtained 3,520 lbs. of hay per acre. *Vianne* obtained from a moist, fertile soil, of a light type, 15,570 lbs.

100 lbs. of grass cut, when in flower, give 42 to 43 lbs. of hay. 100 lbs. of hay, cut when in flower, contain: —

Nutritive value.

	Way.	Ritthausen and Scheven.	Collier.
Albumin	11.6 %	7.5 %	7.2 %
Fibre	28.9 %	40.5 %	21.4 %
Non-nitrogenous extractives .	38.0 %	33.3 %	46.9 %
Fat	2.7 %	1.9 %	3.0 %

Analyses (made at Zurich) of hay from the second cutting, consisting mainly of leaves, gave: —

Albumin (Nitrogen × 6.25)	10.2 %*)
Fibre	25.2 %
Non-nitrogenous extractives	38.0 %
Fat	3.0 %

As yet, there are no data regarding the proportions of organic matter which are assimilable. Comparison of the first and second cuttings, shows that the second is richer in albumin and fat, and has less woody fibre.

Harvesting the seed.

Harvesting, impurities and adulterations of seed. At present, if properly accomplished, there is probably no other grass whose seed-harvest is so profitable as this. The first cutting should be used, because the second produces fewer culms, and does not mature properly. By the end of July, maturity is reached. The proper time for cutting has come when the culms begin to turn yellow beneath the panicle, when the spikelets have assumed a straw-colour, and when the grains have a leathery consistence. If sufficient attention is paid to these points, no seeds are lost during harvesting, because, at this stage, the seeds do not readily detach.

If Cocksfoot is grown by itself, seed can be obtained in the same way as from cereals. The crop is cut with a scythe, allowed to dry for a few days, turned once or twice and made into in small sheaves. If the weather is showery the plants should be formed into stooks, as soon as they are somewhat dry. Then rain can do no damage. If the plants lie on the ground, the seeds are discoloured, and the quality is low. If especially cultivated for seed, the grass is grown in rows, about 1 ft. apart. These when ready, are cut with the sickle, and made into small sheaves. Further treatment goes on under cover in an airy place, the sheaves being arranged across horizontal bars, so that a current of air passes from below upwards. In this way, seed properly ripened and of the highest quality is obtained. In Dauphiny, where most of the seed is produced, it is harvested like False oat-grass (which see). When ripe, the culms are cut about 1 ft. beneath the panicle made into small sheaves, and allowed to ripen in large stooks; the remainder is then made into hay. As with false oat-grass, so here, the seeds are very impure, because they have been obtained from a mixture. The impurities consist mainly of good seeds: *Meadow Fescue, Golden oat-grass, False oat-grass* and a small proportion of chaff and weeds. The average composition of 53 samples of cocksfoot imported from Dauphiny in 1881—82 was as follows: —

Pure seeds	66.9 %	84 % Good seeds.
Meadow Fescue	12.0 %	
Golden Oat-grass and Poas	3.2 %	
False Oat-grass	1.9 %	
Bromes (Mainly *Bromus erectus*)	2.3 %	
Quaking grass, Yellow clover, cereals etc.	0.8 %	
Weeds	2.6 %	
Chaff	10.3 %	
Total	100 %	

---

*) Total Nitrogen = 1.627 %, Non-albuminoid nitrogen = 0.170 %, in hay containing 14 % of water. — *O. Kellner* found the following amounts of nitrogen in cocksfoot of the second year. On the 14th April, height 6 inches, total nitrogen = 5.091 %, non-albuminoid nitrogen = 1.306 %. On the 23rd May, height 22 inches, a total of 2.533 %, the non-albuminoid nitrogen = 0.452 %; all these figures refer to the dry substance.

Cocksfoot seed, obtained on a large scale, has always a higher percentage of purity than this. It is not necessary to grow cocksfoot by itself to get pure seed. A mixture with various clovers can be used; in this way the amount of fodder is increased and pure seed of high quality obtained. However, too much clover should not be used. In Hesse, and neighbouring districts, cocksfoot seed is collected in the woods; the quality is not so high as that of Dauphiny. Seed-threshing is easy, and can be done by hand or machine.

Yield of Seed. Pinkert obtained 528 lbs. per acre, Werner 200—260 lbs.

Impurities. The most frequent impurities are: *Meadow Fescue,* a small proportion of *False oat-grass, Yellow oat-grass,* etc. The presence of these does not lower the value of the seed, since they are good and usually dearer than those of cocksfoot itself. Bromes and weeds are, of course, bad. The weeds are composed mainly of small seeded *Compositæ* (species of *Crepis, Chrysanthemum, Senecio, Lapsana, Hypochœris, Leontodon, Hieracium),* and a few *Umbelliferæ* and *Rubiaceæ.* By means of machinery it is possible to remove the bulk of these injurious and valueless constituents. The following is an analysis of seed cleaned by machine: —

	Uncleaned.		Cleaned.	
Pure seed	63.8 %	Good seeds 86.5 %	86.5 %	Good seeds 97.8 %
Meadow Fescue	14.2 %		10.7 %	
Golden Oat-grass and Poas	5.9 %		0.3 %	
False Oat-grass	2.6 %		0.3 %	
Bromes	1.6 %		1.1 %	
Quaking grass, yellow clovers, cereals etc.	0.9 %		—	
Weeds	0.9 %		—	
Chaff	10.1 %		1.1 %	

Adulterations. Adulterations are now more rare than formerly. Hard fescue *(Festuca duriuscula)* and Purple Melic grass *(Molinia cœrulea)* have been chiefly used. *Hard fescue* is distinguished by the colour, and the rounded back of the outer pale (the outer pale of cocksfoot is keeled), *Purple melic* (fig. 15) is always awnless; the whole fruit is darker in colour, shorter and stouter, especially at the base; the pales gape at the apex and do not overlap.

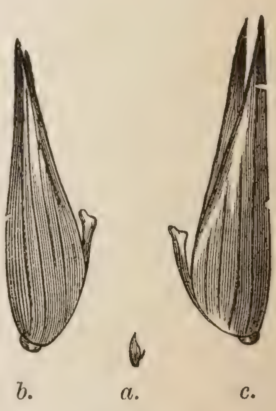

Fig. 15.
Molinia cœrulea, Moench.
False fruit side-view: —
a. natural size,
b and c × 8

Seed quality. **Seed and amounts to be sown.** Cocksfoot has on an average 74.2 % purity, and 54 % germination. Good commercial seed should have 75 % purity (85 % of good seeds), and a germinating power of 70 % (52.5 % of pure and germinating seed).

1 lb. of pure seed contains on an average 579,500 grains. The weight per bushel varies from 12 to 16 lbs.

Amount to be sown. On acre of ground requires 35 lbs. of seed containing 52.5 % pure and germinating seed. The average price is 9d. per lb.; seed for one acre would therefore cost about 26 shillings.

Mixtures. From its tufted mode of growth cocksfoot cannot be used alone. It should be mixed with plants of a spreading nature, which fill up the gaps between the cocksfoot tufts. *Perennial rye-grass, Meadow foxtail,* and *Timothy* are specially appropriate. More or less *clover* should also be added, according to the kind of mixture. In laying down permanent grassland, Clover-grass, and in alternate husbandry, cocksfoot should always be borne in mind. It is best in a ley of 3—6 years. If too large a proportion is used at first, the same drawbacks occur as with a pure sowing, i. e. gaps occur between the tufts, and the grass is cushion-like and unequal. The best plan is to use a small proportion at first, in order to allow the other grasses to develope: later on, additional cocksfoot may be sown. At the beginning, 15 % should not be exceeded.

Rolling and Harrowing.

Rolling is very advantageous in spring. By this operation, the tufts, which are standing higher than the other grass, are pressed down, and the whole becomes more uniform. In old, rich meadows, where cocksfoot is very prevalent, it is advisable to harrow in spring and afterwards to use the roller.

Allied species.

The two following grasses, which have only been cultivated for purposes of experiment belong to the same genus: — 1 Tussock grass, 2. Russian Cocksfoot. Tussock grass *(Dactylis cæspitosa*, Forst.) is indigenous to the Falkland Islands. Attempts have been made to cultivate it in Europe, but, according to Lawson, without satisfactory results. It forms enormous cushions of grass, from which culms, 3 to 4 feet in height, spring out. Russian Cocksfoot *(Dactylis altaica*, Besser.) is somewhat similar to the common Cocksfoot; it is distinguished mainly by its greater height.

IV. Meadow Fescue.

(Festuca elatior, L.)

(Sub-species *pratensis*, var. *genuina* Hackel)

Explanation of plate.

Fig. A. Entire plant in flower.
„ 1. Spikelet in flower, side-view.
„ 2. Flower detached, shewing, 2 lodicules, 3 stamens and the pistil.
„ 3. False fruit, dorsal surface.
„ 4. False fruit ventral surface; shewing the stalk.
„ 5. Caryopsis, dorsal surface, shewing the embryo.
„ 6. Caryopsis, ventral surface shewing the hilum.
„ 7. Diagram of the spikelet.
„ 8. The ligule, and eared leaf-base.
„ 9. Transverse section of a leaf blade, shewing the ribs.

Botanical description.

Meadow fescue is a *tufted* grass; its *lateral branches* are intravaginal and grow up vertically alongside the parent stem. At times, branches break through the sheaths which enclose them, becoming extravaginal; these form partial tufts, and give a more spreading grass, as in fig. A. As no lengthened stolons are produced, the tuft is always compact throughout. The *sheaths* of the radical leaves are purple and shining at the base: when withered they split up into brown fibres.

The *culms* are ascending and smooth, but some times slightly rough beneath the panicle; they reach a height of 18—36 inches; the *leaf-sheaths* are smooth, and glabrous; the *blades* are convolute in the bud, and taper towards the apex; the ribs are distinct on the upper surface; the margins are rough from above downwards (fig. 9). The *ligule* is very short, reduced to a mere margin. The base of the leaf blade is prolonged laterally to form a pair of hook-like ears (fig. 8). The *inflorescence* is a *panicle* 4—8 inches long; the lowest branches are in pairs and each bears from 1—3 spikelets. (In Tall fescue *Festuca elatior* var. *arundinacea*, the weaker basal branch bears 5—8 spikelets.) During flowering the branches are spread out. Each *spikelet* usually bears 7 or 8 flowers (the var. *arundinacea* only 4 or 5); the colour is pale green, and the form, lanceolate. Both *glumes* are short, and about $^1/_3$ as long as the whole spikelet. The lower glume is the smaller and one-nerved (figs. 1 and 7); the upper is three-nerved (figs. 1, 7). The *pales* are two: the *lower* is (figs. 1, 3, 4, 7) 5-nerved with a white scarious margin, rounded on the back, and awnless; the *upper* is (figs. 1, 4, 7) slightly shorter, and has a pair of scabrous keels. The lodicules (figs. 2 and 7) are split at the apex. The *ovary* (figs. 2) is glabrous and deeply furrowed at the apex. On *flowering* the anthers behave as in Perennial rye-grass (which see). At maturity the spikelet breaks up into the *false fruits* (figs. 3 and 4); a portion of the axis of the spikelet remains at the base of each, forming the *stalk* (fig. 4). The length of the *false fruit* is 6 — 7 mm. The flat *caryopsis* (figs. 5, 6) adheres to the pales, particularly to the upper; its length is 3 mm.; it is obtuse at the apex and acute at the base; the ventral surface has a shallow groove, and a long hilum (fig. 6).

Varieties.

Varities. Cultivated Meadow fescue is, from Hackel's standpoint, merely the variety *genuina*. Two subvarieties of agricultural importance can however be distinguished, these are, 1° Typical Meadow fescue which, botanically speaking, is *Festuca elatior* sub-sp. *pratensis*, var. *genuina*, sub-var. *typica* Hackel, and 2° False fescue, *Festuca elatior* L. sub-sp. *pratensis*, var. *genuina*, sub-var. *pseudo-coliacea* Hackel. The latter often occurs wild on roadsides; it is a partially starved variety, which produces simple spikelets on the apical branches, (like *Festuca loliacea)*. This character and the smaller size are the only points in which it differs from the typical variety. It is to be regarded as a local form, produced when the ground is firmly trodden; on a looser soil, it passes into the typical form.

Hybrids.

Festuca loliacea De Cand. is a hybrid between Perennial rye-grass and Meadow fescue; its inflorescence is a spikelike raceme; the branches are reduced, like those of rye-grasses to single spikelets. Meadow fescue also forms hybrids with, Italian rye-grass, and with *Festuca gigantea* Vill. No agricultural interest attaches to any of these hybrids.

Name.

The species, called *Festuca elatior* by *Linnæus*, was more recently divided into two species, viz. Tall fescue *(Festuca arundinacea* Schreber.), and Meadow fescue *(Festuca pratensis* Hudson.). Hackel, in his classic monograph on the European fescues, unites these again into a single species, viz. *Festuca elatior*. This he divides into 2 sub-species: — 1. *Festuca elatior* sub-species *pratensis*, and 2. *Festuca elatior*, sub-species *arundinacea*. Botanically then, Meadow fescue is not a species, but a sub-species, of which the variety *genuina* is the common form.

History.

Meadow fescue has only received a large share of attention within recent years, although its value as a fodder-plant has long been recognised. *Judtmann*, in 1790, speaks of it as an excellent grass. *Mauke*, in 1818, mentions it as one of the best and most useful grasses. According to *Sinclair*, it was first cultivated experimentally in England, about 1820. On the continent, its cultivation commenced as late as 1850.

Agricultural value.

This is one of the most valuable grasses either for mowing or pasture, as it is very productive, and the fodder good. Being perennial, it ought always to be represented on permanent grass lands which are suitable for its growth.

Geographical distribution.

Occurence, climate, soil, manure. Meadow fescue is indigenous — throughout *Europe* (in Scandinavia it extends into south-eastern Lapland, in southern Europe it is rare); to *Asia*, in Caucasus, Georgia and Siberia. Recently it has been introduced into North America. Occurs throughout Great Britain, except Westmoreland, Cumberland and on the Isle of Man; it descends to the coast level and ascends to 600 feet or upwards in the East Highlands of Scotland.

Habitat.

It occurs wild in humid, moist, or even wet ground of good quality, more especially on alluvial soils, by river-banks and roadsides. In Alpine regions, when the soil is suitable, it also occurs wild.

Limits of altitude.

On the Alps, on the moist rich soils at Schwefelberg it has been observed in abundance at an altitude of 4,900 ft. It is the most abundant grass on many alpine districts as at Gurnigel at 3,900 ft. On the Bavarian Alps, it occurs up to 4,600 ft., on the Caucasus, from 1,300—5,250 ft.

Climate.

In appropriate situations neither winter nor late frosts injure this grass. Above everything it requires moisture; water, unless very excessive, does it little injury. Deep valleys, localities where cloud and dew long persist, as in certain mountainous districts are specially suitable. Since the roots penetrate well into the ground, it can tide over a temporary drought, if the soil is deep. In general, drought tends to make it poor and stunted, and so in dry ground, it cannot at all succeed.

Soil.

Meadow fescue thrives best on moist soils which are rich in humus, whether marls, or clays. It can also be grown on sandy soils if they are sufficiently moist, or can be irrigated, as well as on moist calcareous soils. Any drained soil rich in humus satisfies it. Little produce can be obtained from poor soils which are dry, or shallow, or liable to be scorched.

Substances removed from the soil.

According to *Witting*, 1000 lbs. of hay remove from the soil: —

Nitrogen	13.3 lbs.	Magnesia	3.9 lbs.
Phosphoric acid . .	7.4 „	Lime	9.2 „
Potash	25.6 „	Sulphuric acid . .	1.7 „
Soda	5.2 „	Silica	22.8 „

Manure.

From the fact that this grass delights in soils which are rich in humus, it follows that it will thrive best with well rotted manure. Fresh manure is, however, not at all disadvantageous.

Wollny manured a plot of ground with 660 gals. of liquid manure per acre; the produce per acre was:

	Green.	Dry.
Manured plot	11,750 lbs.	2,950 lbs.
Unmanured plot . . .	3,960 „	1,190 „

Irrigation.

Meadow fescue is as well adapted for irrigation as any other grass, and it should always be represented on irrigated grass-land.

Growth.

Growth, Yield, Nutritive value. Meadow fescue forms compact tufts of grass. The culms are numerous and tall, 2 to 3 feet in height. The culm-leaves are also numerous, long, and broad. When the conditions are unfavorable i. e. on dry, poor soils, the produce is much reduced: — the culms become low, and their leaves, short and narrow.

Development.

After sowing, development is relatively slow, the main yield being obtained in the second and third years. *Vianne* obtained the following yield of grass per acre:

1st year	14,740 lbs.
2nd „	28,600 „

It commences to grow early in spring, so that, when soil and season are favorable, 3 good cuttings may be obtained. Sinclair says: »In point of early produce in the spring, this grass stands next to Meadow foxtail«. It comes into flower about the end of May or the beginning of June, a few days later than Cocksfoot and False oat-grass.

Harvest.

It becomes hard after flowering; it is therefore advisable to cut it before that time. The second cutting produces fewer culms, hence the yield is smaller.

Yield.

Sprengel estimates the yield of hay on a good soil at 4400 lbs. per acre. *Pinkert* obtained from a stiff mild sandy loam 4930 lbs. of hay in two cuttings. *Vianne* took from a loam, 6030 lbs. in the first year, and 10,340 lbs. of hay in the second. *Sinclair* obtained from a fertile, peat soil, manured with coal ashes, the following produce per acre: —

	Green.	Dry.
16th April	10,890 lbs.	—
at time of flowering . .	13,612 „	6,466 lbs.

Depasturing

The grass stands depasturing very well. In England, and on the alluvial soils of Northern Germany, it usually forms an important constituent of pasture mixtures.

Nutritive value.

Judged by following analyses, the fodder has considerable nutritive value. 1,000 lbs. of hay contain: —

	Ritthausen and Scheven.	Wolff.	Arendt.	Collier.
Organic Matter	80.3	81.5	79.8	77.9
composed of: —				
Albumin (N × 6,25) . . .	8.3	10.2	6.4	9.2
Fibre	34.5	32.6	—	20.8
Non-nitrogenous extractives .	34.9	36.9	—	45.1
Fat	2.7	1.8	1.8	2.8

Harvesting the seed.

Harvesting, Impurities and Adulteration of seed. It is profitable to produce seed of Meadow fescue, as harvesting is easy and the yield large. Seed should be taken from the first cutting. It is ripe about the end of July, when the pales have assumed a brown tint. The plants are then cut and treated as directed for Cocksfoot (which see).

Yield of seed.

Pinkert obtained 700 lbs. of seed per acre. *Werner* estimates the yield at 200—222 lbs.

Impurities and adulterations.

Commercial seed often contains *Perennial rye-grass,* which, being cheap, is often intentionally added. 50 % or more may be perennial rye-grass. The two kinds of seed are externally very similar and can only be distinguished after long practice. The great point of distinction lies in the stalk. In Meadow fescue it is longer, narrower, *round in section,* and not so closely pressed against the inner pale (fig. 16). In Perennial rye-grass, on the other hand, it is shorter, *broader,* and closely pressed against the inner glume; *the breadth gradually diminishes from the apex to the base.* In seed of Tall fescue *(Festuca elatior)* of commerce, Perennial rye-grass is readily known by its pale. It is flat and awnless, whereas the pale of Tall fescue has a short apical awn.

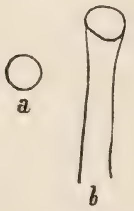

Fig. 16.
Stalk of *Festuca pratensis,* Huds.
Meadow fescue maq.
a. transverse section
b. longitudinal view

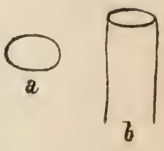

Fig. 17.
Stalk of *Lolium perenne,* L.
Perennial rye-grass (maq.)
a. transverse section
b. longitudinal view

Seed quality.

Seed and amounts to be sown. The average purity of commercial seed is 82 %, and the germinating power 71 %. A good sample, however, should have 95 % purity, and at least 75 % germinating power = 71.3 % of pure and germinating seed.

1 lb. of pure seed contains 318,200 grains, and the best quality of seed 226,400 grains. The weight per bushel varies from 12—26 lbs.

Amount of seed per acre.

To cover an acre of ground with Meadow fescue requires 52 lbs. of seed containing 71 % of pure and germinating seed. The average price of seed is 1/- per pound, and to sow an acre would cost about £ 2. 12/-. It is therefore a relatively dear grass.

Mixtures.

Meadow fescue, unless cultivated for seed, is never sown pure, but always mixed with other grasses. Since full produce is obtained only in the second and third years of growth, it is not suitable for mixing with clovers to form »clover grass«. Its appropriate place is in alternate husbandry and permanent pastures. For irrigated lands and for meadows it can form 20 % or even more of the whole mixture; for short leys, rarely more than 15 %.

V. False oat-grass.

Avena elatior L. or *Arrhenatherum elatius* Mertens & Koch.

Explanation of plate.

Fig. A. Portion of a plant, shewing the contracted panicle.
,, B. Portion of a panicle in flower; the panicle is spreading.
,, 1. Spikelet before flowering, side-view.
,, 2. Spikelet in flower, side-view; to the right is the lower male flower with the awn, to the left the upper hermaphrodite flower.
,, 3. The hermaphrodite flower with the lower pale removed, shewing two lodicules, 3 stamens, the pistil and the upper pale with its keels.
,, 4. Pistil of the hermaphrodite flower, shewing the ovary and the feathery stigmas.
,, 5. Rudimentary pistil of the male flower.
,, 6. The false fruit: to the left is the upper fertile flower containing the caryopsis, to the right the barren male flower with the awn.
,, 7. The same, with the empty pales removed, side-view.
,, 8. The same ventral surface, shewing the stalk.
,, 9. The caryopsis, dorsal surface, shewing the embryo.
,, 10. The caryopsis, side-view.
,, 11. Diagram of the spikelet; the fertile flower below, the barren above.
,, 12. Transverse section of a leaf-blade (after Lund), shewing the low flat ribs.
,, 13. The obtuse ligule; the dots on its outer surface represent the hair.

Botanical description.

Botanical description. False oat-grass forms loose tufts of grass. The extravaginal branches lengthen out somewhat beneath the ground, and form, so to speak, short stolons; this gives the loose character to the grass. The *culms*, 2 to 4 ft. high, are smooth, shining, and erect, or, at times, somewhat ascending at the base. The *leaf-sheath* is glabrous; the *ligule*, short, obtuse, and hairy on the outer surface (fig. 13); the *blade*, narrow and rough, with low flat ribs (fig. 12), and convolute in the bud. The *inflorescence* is a panicle, contracted before flowering (fig. A), but afterwards widely spreading (fig. B). The spikelets are numerous, and of a whitish-green colour, often tinged with violet and brown. The *spikelet* contains two flowers: — the lower male and awned, the upper hermaphrodite and usually awnless (figs. 2 and 11). The *glumes* are two: — the upper, longer than the other, and three-ribbed; the lower, narrower and one-ribbed (figs. 1, 2 and 11). Each flower has two *pales*. The lower pale of the male flower is furnished with a long awn, which is bent and twisted, and arises near the base of the pale (figs. 1, 2 and 6). The *lower flower* has 3 stamens, and a rudimentary pistil (fig. 5) on which the stigmas are not represented; it is, therefore, barren or male. The *upper flower* has 3 stamens, and a pistil with feathery stigmas (figs. 3 and 4), i. e. it is hermaphrodite and fertile. Both flowers have lodicules (figs. 3 and 11). The axis of the spikelet is prolonged beyond the base of the upper flower, forming the stalk (fig. 8). *Flowering* goes on as in Perennial rye-grass (which see). At maturity, the contents of the spikelets detach, and the glumes are left empty behind. The two ripe flowers of the spikelet, together with their pales, remain united, and form the *false fruit*: it is composed of a pair of empty pales from the lower flower, and a pair of pales containing a caryopsis derived from the upper flower (fig. 6). When the empty pales are removed (fig. 7), the fruit stands on a short hairy stalk, which is prolonged along the inner face of the upper pale (fig. 8). The *caryopsis* (figs. 9 and 10) is fusiform, and acute at the apex and base; the ventral surface has no furrow; at the base of the dorsal surface lies the embryo; the apex has a few short hairs.

Varieties.

A variety of this is the common weed known as bulbous-rooted oat-grass (*Arrhenatherum elatius* var. *bulbosum*, Koch.) This variety occurs mainly on moist sands and loams, and, in such localities, is often a very execrable weed. The short internodes at the base of each culm swell out, and become rows of tubers hence the name bulbous-rooted. The tubers in each row vary in number from 2 to 5. This is smaller than the cultivated variety; the leaves are also shorter, and of a lighter green colour. It is an error to suppose that on a light soil, the cultivated becomes the bulbous variety; and, that on a stiff soil, the bulbous variety reverts to the normal type. Such a change does not occur, as the bulbous-rooted variety always reproduces itself when grown from seed.

Name. Various common names are applied to False oat-grass, e. g. Tall oat-grass, French rye-grass, etc. In Dauphiny and France it is called »Fromental«.

History. Towards the beginning of last century, False oat-grass was cultivated in Dauphiny, in the neighbourhood of Geneva, and here and there in canton Berne. *Stapfer*, in a memoir presented to the Agricultural Society of Berne in 1762, strongly recommended its cultivation. In 1790, *Judtmann* advocated its use for mixing with red clover, sainfoin, and lucerne. Later it became much over-estimated e. g. by *Mauke*, *Hansen* and *Hannemann*. The French, as *Schwerz* says »elated it to the skies«. Soon, however, it became as much depreciated as it had formerly been over-estimated; *Hector* in his work on grasses does not even mention it.

Agricultural value. This is one of our best fodder grasses. It constitutes a good »top« grass and should never be absent from a mixture, unless when the ground is too moist. For mixing it is excellent, but for pasture it is not very suitable.

Geographical distribution. **Occurence, climate, soil, manure.** This grass is indigenous — to *Europe*, extending to Southern Norway, Sweden and Finland; to *Africa*, in Algeria and Madeira; to *Asia*, in Caucasus, Georgia, Armenia and Talusche. It is neither indigenous to *N. America* nor *Australia*. Occurs throughout Great Britain, from Cornwall and Kent to Shetland, Orkney and the Hebrides, from the coast level to 1300 feet, in the Scottish Highlands.

Habitat. It occurs wild, in good meadows and pastures, in hedges, on the borders of woods and roads, in fields, etc.

Limits of altitude. On the Bavarian Alps it ascends to 2,400 ft., on the Caucasus to 2,600 ft., in Talusche to 3,280 ft., and in Armenia to 5,250 ft.

Climate. False oat-grass can succeed in dry ground, provided it is deep and not too stiff: the roots then penetrate to the deeper layers. Although it can withstand drought very well, still, when the soil is dry and poor, the plant becomes stunted and the yield is small. Too much moisture is destructive.

Soil. It thrives best on moist loamy sands, on loams, on mild clays which are not too moist, and on marls. It can also be grown on some moorlands, but then it is often uncertain.

Substances removed from the soil. According to Arendt's experiments 1000 lbs. of hay remove from the soil: —

Nitrogen	18.4 lbs.	Lime	3.8 lbs.
Phosphoric acid . .	5.0 ,,	Silica	27.8 ,,

According to Wolff's analyses, 1000 lbs. of hay remove on an average, 17.8 lbs. of nitrogen; according to the Zurich analyses, only 15.2 lbs.

Manure. A liberal supply of manure is very advantageous for this grass. *Wollny* applied 660 gals. of liquid manure per acre to a plot of False oat-grass; a similar plot was left without manure; the following results were obtained: —

	Green.	Hay (containing 14 % water)
1. Manured plot . .	16,190 lbs.	3830 lbs.
2. Unmanured plot .	9,940 ,,	3170 ,,

When manured with 660 gals. of liquid manure, an increase of 660' lbs. of hay per acre, was the result. Each gallon of liquid, therefore, gave an increase of 1 lb. of hay.

The hay from the manured plot was, however, of superior quality, and contained 9.7 % of albumin, whereas that from the unmanured plot, contained only 7.3 %. Similar results were obtained with a seed crop, as shown by the following figures: —

	Seed.	Hay.
Manured plot	145 lbs.	4664 lbs.
Unmanured plot	93 „	4050 „

Growth.

Growth, Yield, Nutritive value. False oat-grass forms loose tufts of grass, so that the ground is thinly covered. For this reason, it should be mixed with other grasses, to thicken the sward. After sowing development is very rapid, and considerable produce is obtained even in the first year; in the second year the yield reaches its maximum.

Karmrodt obtained the following produce per acre: —

1st year	6,470	lbs. of hay
2nd „	15,270	„ „ „
3rd „	10,384	„ „ „
4th „	7,524	„ „ „

The yield is thus at its maximum in the second year and then gradually diminishes.

Harvesting.

This is one of the early grasses, which comes into flower about the beginning of June. It should be cut early, because the culms begin to harden soon after flowering.

Yield.

On good soils 3 to 4 cuttings are obtained, but on medium kinds, only two. The produce of the first cutting is largest, since in the aftermath fewer culms are produced. *Sinclair* obtained, from a loamy clay, the following yield per acre: —

	Green.	Dry.
During flowering	17,015	6,380
Aftermath	13,612	—

From two cuttings, *Pinkert* obtained 6,340 lbs., and *Karmrodt*, taking an average over 4 years 9,940 lbs. *Sprengel* estimates the yield at 8,800 lbs. 100 lbs. of grass give 32 lbs. of hay.

Nutritive value.

According to *Wolff* 100 lbs. of hay contain 75.8 % of organic matter, composed of: —

Albumin (N × 6.25)	11.1 %	portion assimilable	5.6 %
Fibre	29.4 %	„ „	33.1 %
Non-nitrogenous extractives	32.6 %		
Fat	2.7 %	„ „	0.8 %

Ratio of nitrogenous to non-nitrogenous nutriment 1 : 6.3.

The taste of the fodder is bitter, so that, especially when green, it is not readily eaten by cattle. This is sufficient to indicate that it should only be used in mixtures with other grasses and clovers. As hay it has some specially good points: — it dries readily, and when dry, keeps well.

Harvesting the seed.

Harvesting, Impurities and Adulteration of seed. In this case, the production of seed is very profitable, since the yield is large, the harvesting easy, and the price high. For a seed-crop, light warm soils are most suitable. The seed is harvested like that of cereals. The ripe plants are cut with a scythe, dried, bound in small sheaves, allowed to ripen, in an airy place, and then threshed. The seed is known to be ripe when the panicles assume a yellowish tint, and when the grain is beginning to have a leathery consistence, which occurs soon after the milky stage. Early cutting is preferable to late; with late cutting, seed easily falls out, and is lost. Although cut early, a full seed-crop may be obtained, if the sheaves, after drying, are allowed to mature in the barn. In Dauphiny, the culms are cut off about 1 ft. beneath the panicle and bound into sheaves as thick as the arm. These are formed into large stooks (fig. 8), and after standing on the field for 10 or 14 days, are mature. The seed is then threshed out.

Yield of seed.

Pinkert, obtained 880 lbs. of seed per acre, *Wollny* only 88—130 lbs. *Hanneman* and *Werner* estimate the average yield at 260—350 lbs. per acre. Assuming the selling price to be £ 2.10 per cwt., an acre would give a return varying from £ 5 to £ 7.

In a dry season the yield is most certain. In a wet season, the grass is easily laid, and this, of course, diminishes the yield very much. Hence southern countries, where summer rains are less frequent than in our own, are best adapted for producing the seed of this grass. Commercial seed is usually imported from Dauphiny: it is often very impure, as it is not obtained from a pure crop, but from the natural meadows, where it occurs in mixture with other grasses. These are of course cut with the oat-grass and constitute the impurities.

Impurities.

During the seed-season of 1881—82 the average composition, taken from 84 analyses made at the seed control station of Zurich, was as follows: —

1. Pure seed	65.0 %	73.9 % good seeds.
2. Cocksfoot	6.6 %	
3. Meadow and other Fescues	1.6 %	
4. Yellow oat-grass and Poas	0.7 %	
5. Bromes *(erectus, mollis)* etc.	13.6 %	
6. Quaking grass, yellow clover etc.	0.8 %	
7. Weeds	0.9 %	
8. Chaff	10.8 %	
Total	100.0 %	

It is thus apparent that the value of False oat-grass seed depends not only on the amount but on the nature of the impurities. Good seeds such as Cocksfoot do not decrease the value, whereas a large percentage of Bromes or chaff considerably diminish it. The worst impurities are the Bromes, which frequently form 20—30 % of the whole. The poorest qualities of seed, are usually sold as »*fenasse*«, better kinds as »*petit fromental*«. 12 analyses of »*fenasse*«, made in 1881—82, gave on an average: —

False oat-grass	19.9 %	41.5 % good seeds.
Cocksfoot	13.0 %	
Meadow fescue, including a small proportion of Perennial rye-grass	3.4 %	
Yellow oat-grass, Poas	2.6 %	
Sainfoin	2.6 %	
Bromes (mainly *erectus*. with *mollis* etc.)	28.9 %	
Quaking grass, *Holcus*, yellow clover etc.	1.9 %	
Weeds	1.3 %	
Chaff etc.	26.4 %	
Total	100.0 %	

It is thus seen that »*fenasse*« consists very largely of chaff, and Brome grasses; the Bromes have of course no value, and must be reckoned as worthless weeds. Nevertheless, in many parts of Switzerland, »*fenasse*« is sown in great quantity. In the year of sowing, the crop obtained consists of False oat-grass, while in the second year *Bromus erectus* and Cocksfoot come forward and produce their culms. The distinction then between »*fenasse*« and »*petit fromental*« consists only in the larger percentage of Bromes and chaff in the former.

Cleaning the seed.

At Herisau in Switzerland, a machine has lately been devised for the purpose of eliminating impurities. The smaller seeds of False oat-grass itself are also separated. The following analyses show the results obtained by this machine: —

	False oat-grass %	Cocksfoot %	Meadow Fescue %	Yellow oat-grass %	*Bromus erectus* %	*Holcus* %	Weeds. %	Chaff. %
Uncleaned seed	44.1	8.6	2.9	0.6	13.0	2.9	2.9	25.0
Cleaned seed	83.1	0.3	0.9	0.3	9.9	—	1.2	4.3

Adulterations.

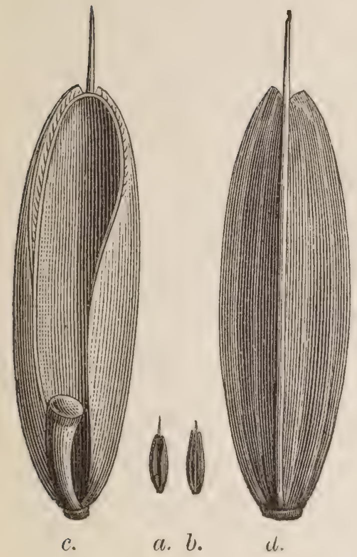

Fig. 18.
Rye Brome grass,
Bromus secalinus, L.
False fruit, *a. b.* natural size.
c. d. × 8.

Rye brome (*Bromus secalinus*, L.) which has been cleaned from cereals, especially Rye, is sometimes used as an adulterant. The seed of Rye brome (fig. 18) is readily detected. It is not round like False oat-grass, but has a distinct inner and outer surface; the inner is concave, the outer, rounded. The caryopsis is large, and loosely attached between the pales. The outer pale is seven-ribbed, and its midrib is usually prolonged into a short awn. The inner pale has bristle-like hairs along the margins.

The Darnel (*Lolium temulentum*, L.) will usually be found when the cleanings of Rye are used as adulterants. The seed of Darnel (fig. 19) is thick and swollen, and 5 or 6 mm. long; the outer pale has a long apical awn. A few Rye seeds will usually be found; as they are pointed, some pass through the sieves with the cleanings.

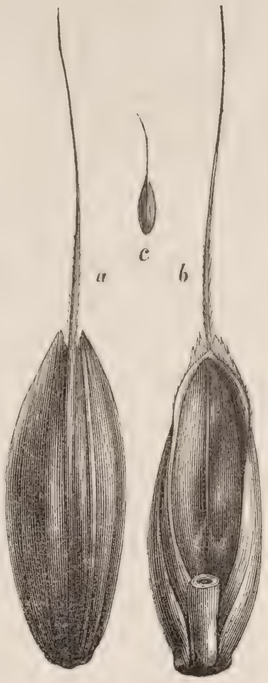

Fig. 19.
Darnel,
Lolium temulentum, L.
False fruit, *a.* dorsal surface
b. ventral surface × 7,
c. natural size.

Seed quality.

Seed and amounts to be sown. The average purity, calculated from 250 analyses is 65.8 % and the germinating power, 63 %. Good commercial seed should, however have a purity of 70 %, and a germinating power of 70 % = 49 % of pure and germinating seed. The Bromes should not exceed 10 %. 1 lb. of pure seed contains 159,000 grains. The weight per bushel is about 10 lbs.

Amount of seed per acre.

An acre of ground requires 70 lbs. of seed containing 49 % pure and germinating = 34.3 lbs. of pure and germinating seed. The price of seed per lb. being about 4d. to sow an acre will cost about 23 shillings for seed.

Sowing.

False oat-grass, because of its large seed, and the robust seedling which it produces, can be sown deeper than other grasses. The most suitable depth is 1 inch in a moist soil, and 1½—2 inches in a dry one. Spring is the most favorable seed-time; but in countries where the early summer is dry, it may with advantage be sown in September. Since the root system penetrates deeply, the plant succeeds best in deep ground where the roots have full scope. The produce diminishes as the soil becomes thinner and firmer.

Mixtures. For fodder, False oat-grass should be sown only in mixtures. Pure sowing has various drawbacks: — the seed is too expensive, the quality of the produce is inferior to that of a mixture, and the duration is shorter. A proper percentage added to a mixture increases the »top grass« and for this purpose False oat-grass is very appropriate. It is specially suitable for short leys or permanent pastures on warm soils with a warm exposure. In such cases it may form as much as 20 % of the whole mixture. As the soil becomes heavier and as the amount of moisture increases, the percentage of this seed should be diminished. Mixed with clover it is not so valuable for a one year ley as Italian rye-grass, but for a clover ley of 2 or 3 years, it is more suitable, and gives a larger yield.

Allied species. Externally it somewhat resembles Downy oat-grass *(Avena pubescens)*. The latter is distinguished, by its shorter leaves, by its culm becoming red after flowering, and more especially by the hairy sheaths of its radical leaves. The fruit is more slender, and has long hair on the base and stalk; the colour is also darker.

VI. Yellow oat-grass.

Avena flavescens, L. or *Trisetum flavescens*, P. de Beauvois.

Explanation of plate.

Fig. A. Entire plant, with the panicle somewhat contracted.
,, B. Panicle in flower, spreading.
,, 1. Spikelet in flower, side-view, shewing the hairy axis and three flowers.
,, 2. Flower, with lower and upper pales.
,, 3. Flower and upper pale, shewing the two lodicules, and the pistil.
,, 4. False fruit, side-view.
,, 5. The hairy stalk detached.
,, 6. False fruit, ventral surface, shewing the pair of bristles at the apex of the lower pale.
,, 7. Caryopsis, side-view.
,, 8. Caryopsis, transverse section.
,, 9. Diagram of the three-flowered spikelet.
,, 10. The ligule.
,, 11. Transverse section of a leaf-blade (after Lund), shewing the ribs and the hair.

Botanical description. Yellow oat-grass forms a loose tuft of grass (fig. A). The *lateral shoots* are at first intra-vaginal, but they soon burst the sheaths which enclose them. The internodes beneath the ground rarely lengthen out into stolons. The *culm* is erect, often slightly hairy beneath the nodes, and may reach a height of two feet. The *leaf-blades* are flat, soft, finely ribbed, and more or less hairy (fig. 11). The *leaf-sheath* is also hairy, especially at the base (fig. A.). The *ligule* is short and obtuse (fig. 10). The *inflorescence* is a panicle, narrow and contracted when young, but on flowering the branches spread out (fig. A). The spikelets are then shining and golden yellow, but later, they become somewhat brown. The branches are very fine and somewhat rough. The *spikelets* are numerous and small, usually three-flowered (figs. 1 and 9) and cylindrical before flowering; later, the flowers spread out, the cylindrical form is lost, and the colour becomes golden yellow. The *axis of the spikelet* is hairy (fig. 1). The *glumes* are two, shorter than the pales; the lower (figs. 1 and 9) is one-ribbed and half as long as the *upper*, (fig. 1, 9) which is three-ribbed, and lanceolate. The *lower pale* (fig. 1, 2, 4, 6, 9) is five-ribbed, and bifid at the apex; a fine bent awn longer than the pale (fig. 1, 4, 6) springs from its back. The two bristle-like teeth formed by the bifid apex of the pale (fig. 6) along with the awn, form 3 bristles, hence the generic name *Trisetum*, which is sometimes applied to this grass. The *upper pale* (figs. 1—4, 6, 9) is membranous, and as usual, two-keeled. The *lodicules* are two (figs. 3 and 9) obtuse and truncated, at the apex, and almost as long as the ovary. The *stamens* are three. The *ovary* is elliptical and glabrous: the *stigmas* are two, sessile and feathery.

Flowering goes on as in Perennial rye-grass. The *false fruit* i. e. the caryopsis enveloped by the pales (fig. 4), is 5—6 mm. long, including the awn, about 10 mm.; the *stalk* (figs. 5 and 6) is somewhat flat and very hairy: a tuft of short hair also occurs at the base of the lower pale. The *caryopsis* is spindle-shaped (fig. 7), compressed, and without a furrow on its inner face (fig. 8).

Name.

The name Yellow or Golden oat-grass refers to the colour which the spikelets assume at the time of flowering. Yellow oat-grass should not be confounded with Narrow-leaved oat-grass, which is of much less value.

History.

This grass has only come into use in recent times. Although its value has long been recognised, the seed was not obtainable in commerce. Probably for this reason *Schwerz* makes no mention of it in his »*Practical Agriculture*«. Recently, however, on *Stebler's* advice, the seed merchants of Dauphiny have been induced to separate the seed, on a large scale, from Cocksfoot so that now the use of Yellow oat-grass has become quite general in Switzerland.

Agricultural value.

Yellow oat-grass is very valuable for temporary and still more for permanent pastures; it yields good fodder which is readily eaten by stock, gives a tolerably large produce in the first and second cuttings and lasts long. It can be cultivated on almost all classes of soil, except those of extreme types. The yield is certain whether the season be wet or dry.

Varieties.

Three varieties are distinguished by botanists: — 1. the common variety, *Avena flavescens*, var. *vulgaris* Alefeld. 2. The large variety, *A. f.* var. *major*, Schrader. 3. The variegated variety, *A. f.* var. *variegata*, Gaudin. The second and third are rarer than the first variety. The variegated form is frequently met with on the Alps. At present the first variety is alone cultivated.

Geographical distribution.

Occurrence, Climate, Soil, Manure. Yellow oat-grass is indigenous — to almost all *Europe*, except Lapland; to *Africa*, in Algeria; to *Asia*, in Caucasus, Georgia, Armenia, Siberia, and Kamschatka. It is not indigenous to *N. America*. It is common in England, but not common in the south and middle of Ireland and scarce in Scotland. Its north limit in Britain is Aberdeen, Forfar, and Stirling, in Ireland the 55th or 56th parallel. In England it ascends from the sea level to an altitude of 400—600 feet.

Habitat.

It occurs frequently in grass-land and on roadsides. It is very common on good pastures in valleys and low lying lands, on the slopes, summits, and valleys of the Alps and Jura, extending to high altitudes. *Langethal* states that its occurrence indicates grass-land of good quality.

Limits of altitude.

On the Alps it reaches the following altitudes: — Reculet (Jura) 4,900 ft.; Fimberthal 5,900 ft. Upper Engadine 5,900 ft.; Langwies and Churwalden 4,260 ft. According to *Brügger*, the normal form is rarely met with above 4,600 ft.; at greater altitudes the variegated variety, *Avena f.* var. *variegata*, replaces it ascending to 7,800 ft.

Climate.

This grass succeeds best in the vine regions. Drought stunts it somewhat, but on the whole it is not very readily affected. Stagnant water is injurious, and in moist seasons yellow oat-grass is less abundant than usual.

Soil.

This grass succeeds best on marly or calcareous soils which are rich in humus, moderately moist and deep. It also thrives on loams and good clays, as well as on loamy sands. In Dauphiny, where the soils are rich and calcareous, it is very abundant and reaches great perfection, its culms often attaining a height of 3—4 ft. It can be cultivated on the better kinds of drained soils containing humus, especially when they are marled or limed. On dry poor land the produce is very scant.

Substances removed from the soil.

According to *Way* and *Ogston*, 1000 lbs. of hay remove from the soil: —

Nitrogen	10.1 lbs.	Magnesia	1.4 lbs.
Phosphoric acid .	4.2 ,,	Lime	3.6 ,,
Potash	16.4 ,,	Sulphuric acid . .	1.8 ,,
Soda	0.6 ,,	Silica	16.0 ,,

Manure.

Irrigation is advantageous, provided that the water does not stagnate. Fresh manure does not give such good results as that which is old and well-rotted. It would seem, that top-dressing with liquid manure is less suitable for this than for most other grasses; however on this point, the experimental evidence is not quite complete. Manuring in autumn, with farm-yard manure, is very beneficial.

Growth.

Growth, Yield, Nutritive value. Yellow oat-grass vegetates luxuriantly, and forms loose tufts with numerous leafy culms.

Development.

It is a moderately early grass, flowering about the middle of June. In the second cutting numerous culms are produced; some agriculturists even assert that the second yields more than the first cutting; this is not usually the case among grasses. However that may be, the second cutting is very productive — a very valuable property. This results from the late and slow development of the first cutting in comparison with other grasses.

Yield.

From a clay loam, *Sinclair* obtained the following yield per acre: —

	Green.	Dry.
On flowering	8,167 lbs.	2,859 lbs.
At the time the seed is ripe	12,251 ,,	4,900 ,,
Aftermath	4,083 ,,	—

Vianne obtained, on a moist, fertile, medium soil, 5,020 lbs. of hay per acre. 100 lbs. of grass give 32.5 to 34.7 lbs. of hay. Compared with some other grasses, the yield is thus somewhat small.

Nutritive value.

100 lbs. of hay contain 80.6 lbs. of organic matter, composed of: —

Albumin ($N \times 6.25$) . . .	6.8 %
Fibre	33.0 %
Non-nitrogenous extractives .	38.8 %
Fat	2.0 %

The proportion of albumin is low; further analysis is however necessary.

Harvesting the seed.

Harvesting, Impurities and Adulteration of seed. The harvesting of this seed is very difficult, and the yield small. Hence Yellow oat-grass is not grown by itself as a seed crop. It is more profitable to separate the seed from that of Cocksfoot, by sieves of appropriate size. In Dauphiny, it is usually grown along with Cocksfoot. Both grasses are cut and threshed together and the seeds separated by sieves. Formerly, when Yellow oat-grass was not in demand, its seeds were not separated at all.

Impurities.

Procured in this way it is necessarily very impure, as various constituents are sifted from the Cocksfoot seed along with yellow oat-grass seed. The proportion of impurities is, on an average, 65 %, and at times even 90 %. These consist mainly of empty pales of Cocksfoot,*) debris of awns and pales, and 5 to 10 % of small seeds of different weeds, such as the Ox-eye daisy *(Chrysanthemum leucanthemum,* L.) and other *Compositæ*, species of *Galium*, etc. A trial of seed containing weeds was made at the Zurich experimental station. The Yellow oat-grass came up well, while the weeds remained in abeyance and were scarcely noticeable. This trial shewed, that the produce is not essentially injured by the presence of certain weeds.

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*) These constitute an impurity, not an adulteration, as they have not been intentionally added to the seed of *Avena flavescens.*

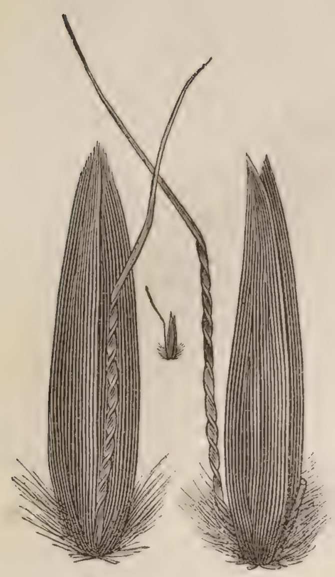

Fig. 20.
Wavy hair-grass.
Aira flexuosa, L.
a. False fruit, natural size;
b. the same, dorsal surface;
c. the same, side-view × 8.

Adulterations.

The seed of wavy hair-grass (*Aira flexuosa*, L.) is often substituted for that of Yellow oat-grass. The *Aira* is very common on dry, barren soils, on sands and heaths, on wood-clearings, etc. It produces a tuft of bristle-like leaves, and slender culms, 8—12 inches high. The produce has no value as fodder, and sheep will scarcely touch it. In July and August the seed is ripe, and about this time, the seed merchants buy it at a cheap rate. The seed of Wavy hair-grass (fig. 20) is easily recognised, when examined by a lens. The pales are reddish-brown and much darker than those of Yellow oat-grass; a bent awn springs almost from the base of the lower pale. Its seed is about twice as heavy as that of Yellow oat-grass.

Quite recently the seeds of *Calamagrostis arundinacea*, Roth. (fig. 22) have come into the markets as Yellow oat-grass. This is recognised by the ashy-grey colour. As in Yellow oat-grass, the bent awn springs from the back of the lower pale, and the stalk is hairy. These adulterants are never mixed with one another nor with Yellow oat-grass seed. The pure *Aira* or the pure *Calamagrostis* seed is brought into the market, and sold as that of Yellow oat-grass.

Seed quality.

Seed and amounts to be sown. The average purity is 34.4 % and the germinating power 37 %. Good seed should have 40 % purity and 40 % germination = 16 % of pure and germinating seed. 1 lb. of good seed contains on an average 2,045,000 grains, of which 327,260 are pure and germinating. The weight per bushel is 5 to 5½ lbs. An acre of ground requires 29 lbs. of seed containing 16 % pure and germinating = 4.64 lbs. of pure and germinating seed. The price per lb. is 2s. 6d. the average cost of seed per acre would then be about £ 3. 12s. 6d. Sinclair says: »I have sown the seeds of this grass in almost every month of the year, and after making due allowance for the state of the weather, the third week in May, and from the first week of August to September, were evidently the best«. Sown alone, the produce is small, and the grass very loose and thin.

Quantity of seed per acre.

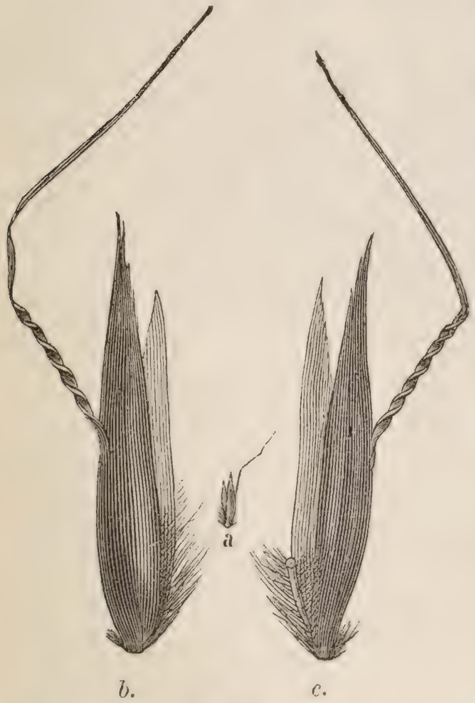

Fig. 21.
Yellow oat-grass, *Avena flavescens*, L.
False fruit: — *a.* natural size,
b. c. × 8.

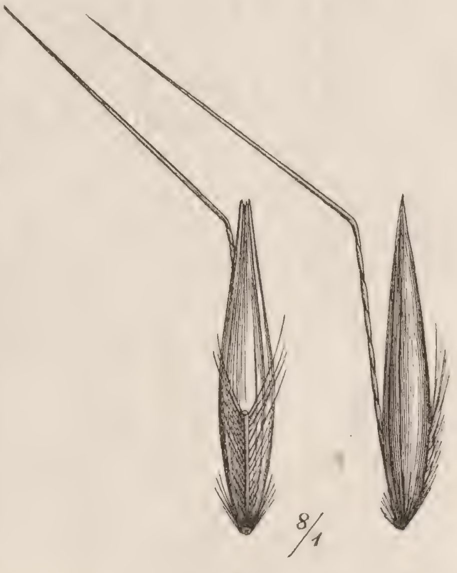

Fig. 22.
Calamagrostis arundinacea, Roth.
False-fruit: — *a.* ventral surface, with the stalk, *b.* side-view.

Mixtures.

For this reason, it should be used only in mixtures with other grasses. It cannot profitably be used for short leys, as its seed is too costly, and the produce too small. On the other hand it is very appropriate for permanent grass-lands, and in mixtures for such, if the soil is suitable, it should always be represented.

VII. Yorkshire fog.

Holcus lanatus, L.

Explanation of plate.

Fig. A. Two entire plants; the panicle to the left being taken before flowering, the panicle to the right during flowering.
,, 1. Spikelet in flower, side-view.
,, 2. The same, with the glumes and stamens removed.
,, 3. Upper pale and lodicules of the hermaphrodite flower, side-view.
,, 4. The same with the stigmas, seen from the front.
,, 5. Pistil of the hermaphrodite flower.
,, 6. Rudimentary pistil of the barren flower.
,, 7. Spikelet in fruit *i. e.* False fruit.
,, 8. The same, with the glumes removed, shewing the axis of the spikelet, the lower fertile flower, and the upper barren flower.
,, 9. The fertile flower with the lower pale removed.
,, 10. The fertile flower, ventral surface.
,, 11. Caryopsis, side-view, shewing the embryo at the base.
,, 13. Diagram of the two-flowered spikelet.
,, 14. Portion of the culm with leaf-sheath, blade and ligule.
,, 15. Transverse section of the leaf-blade, shewing the ribs and the hair.

Botanical description.

Yorkshire fog forms tufts of grass which stand well out of the ground and form cushions. Those branches which are extravaginal ascend almost directly above ground, and there produce partial tufts. The whole tuft is composed of these partial tufts lying over one another, and compacted together. In this way, the projecting cushions of grass are formed. The sheaths of the radical leaves are somewhat red, especially the veins, and by this character the grass may often be recognised. The culms are 18—36 inches high, erect, and hairy beneath the nodes. The *leaf-sheaths* and *blades* are clothed with soft hair, which gives a greyish-green colour to the whole plant (fig. A). The *ligule* is short and obtuse (fig. 14). The *blade* is finely ribbed on the upper surface (fig. 15). The *inflorescence* is a panicle; whilst young contracted and with a reddish tinge, but, on flowering, the branches become spread (fig. A). The *spikelets* are two-flowered. The *lower flower* is hermaphrodite and awnless, the *upper* male and awned (figs. 2 and 13). Rarely, 3 flowers occur in a spikelet; then one is hermaphrodite, and two are male. The *glumes* are two, and of a white colour, often slightly tinged with red towards the apex; under the lens they appear dotted (fig. 7). The lower glume is smaller than the other and one-ribbed (figs. 1, 7, 13); the upper is three-ribbed (figs. 1, 7, 13); both are compressed and have ciliated keels; at its apex, the *keel* is prolonged so as to form a small awn-like point or mucro. At first, the *axis of the spikelet* (fig. 2. 8) runs horizontally towards the upper glumes; it then curves upwards and is continued by a vertical prolongation to the base of the male flower. At the end of the curve lies the hermaphrodite flower with a tuft of hairs (half as long as the pales) at its base. Although the internodes of the axis are long, the pales are comparatively short, so that the glumes completely cover them (fig. 1. 7.) The *lower pale* (figs. 1, 2, 8, 10, 13) of both flowers is ribless, white, shining, and rounded at the apex.

The *lower pale of the male flower* has a dorsal awn (fig. 2) which is not sufficiently long to project beyond the upper glume (Distinction from *Holcus mollis). The lower pale of the hermaphrodite flower* is awnless. The *upper pales* (figs. 2, 3, 4, 10, 13) have no keels. The *lodicules* are 2 (figs. 2—4, 13), comparatively large, almost twice as long as the ovary of the fertile flower, broadly ovate at the base, and tapering to the apex. The *pistil* of the hermaphrodite flower (fig. 5) is composed of an ovary, hairy at the apex, and a pair of feathery stigmas. The *rudimentary ovary* of the male flower (fig. 6) is much smaller, and has only rudimentary stigmas.

Flowering goes on as in Perennial rye-grass. At maturity, the whole spikelet simply detaches from its stalk and forms the *false fruit,* composed of a grain enclosed in a pair of pales, the pales of the barren flower, and the glumes (fig. 7): its length, taking the short awn or mucro of the glumes into account, is 4—5 mm. The caryopsis enclosed in its pales (fig. 10) is 1—2 mm. long, hairy at the base, and almost completely surrounded by the white and shining lower pale: on its ventral face lies the stalk, a remnant of the axis of the spikelet. The *true fruit* or *caryopsis* is oblong-ovate, slightly hairy at the summit, and with a groove on the ventral surface (fig. 11, 12). At maturity the awn of the male flower is bent and hook-like (fig. 8), but during flowering it is quite straight (fig. 2).

Name.

Yorkshire fog is sometimes known as *Woolly soft-grass.* It is called »Yorkshire fog« because it is a very common and pestilent weed on the light soils of Yorkshire.

History and agricultural value.

Yorkshire fog is perennial. As a fodder-plant it is of little value. *Schwerz* mentions it as a very mediocre grass, yielding tasteless hay of little nutritive value. *Sinclair* says, »the numerous downy hairs which cover the surface of the whole plant, render the hay soft and spongy, and in this state it is disliked by cattle, particularly by horses«. Other agricultural writers speak of it as an excellent fodder-grass. *Hansen* says, »this is a very soft sweet and sappy grass, which when green, is much sought after by cattle and sheep. Cut and dried at the proper time i. e., before the panicle is fully spread, and before flowering, it yields a hay, which is surpassed by no other grass, and well liked, especially by horses.« The most competent authorities, however, agree in regarding *Holcus* as a worthless grass on all good soils, where better plants will thrive.

Geographical distribution.

Occurrence, Climate, Soil, Manure. Yorkshire fog is indigenous — to Portugal, Spain, Italy, France and to the whole of Central, Eastern, and Northern *Europe,* except Iceland and Lapland; to *Africa* — in Algeria; to *Asia* — in Caucasus, Georgia, Siberia (Ural, Baikal). It has been introduced into *N. America.* Occurs throughout England, Scotland and Ireland. »Perhaps without exception the commonest of the British grasses, or one that would be so, if the land were left in a state of nature, instead of being converted into ploughed fields and artificial meadows.« (Watson)

Habitat.

It occurs on all classes of soil, in meadows and pastures, the margins of woods, etc.

Limits of altitude.

On the Jura, it reaches an altitude of 4,600 ft., on the Bavarian Alps, 2,450 ft., and on the Alps of Glaris and Grisons, 5,600 ft.

Climate.

Winter-frost frequently affects the plant, but does not quite kill it. As Yorkshire fog shoots rather early, late frosts are also injurious. In moist climates and seasons, the woolly character of the plant becomes more or less lost, and then, of course, the produce is more readily eaten by stock. In drier climates and soils, the hairy character becomes more pronounced.

Soil.

In wood-clearings the plant reaches its highest development, and on rich soils of a loose type, it becomes, as in Yorkshire, one of the most pestilent weeds, since it is self-sowing, and suppresses plants of better quality and larger yield. Its cultivation ought only to be attempted on peaty soils, and on poor sands, where better plants cannot thrive. In such cases it is valuable for covering bare spots.

Substances removed from the soil.

1000 lbs. of hay remove from the soil: —

Nitrogen	14.3 lbs.	Lime	4.1 lbs.
Phosphoric acid	4.5 ,,	Magnesia	1.5 ,,
Potash	20.5 ,,	Silica	26.9 ,,
Soda	2.1 ,,	Sulphuric acid	2.2 ,,

In comparison with other grasses, Yorkshire fog removes from the soil a large proportion of potash; further analyses are however necessary.

Manure.

Although it thrives on well-manured land, its produce does not repay manuring.

Growth.

Growth, Yield, Nutritive value. This grass forms cushion-like, compact tufts, which are very difficult to mow. Its tufts are a great eyesore in a good meadow. Numerous culms 2—3 ft. in height are produced. *Holcus* as already mentioned, is a comparatively early grass, since its leaves are out in March and its flowers in May. When cutting is delayed till after flowering, much nutritive value is lost, seed falls into the ground, and the plant reproduces itself. Its seed forms one of the main constituents of »hay flowers«; sometimes as much as 50 % is unripe *Holcus*.

Development.

Yield.

Sinclair obtained the following produce, per acre, from a clay loam: —

	Green.	Dry.
At middle of April	4,764 lbs.	—
On flowering	19,057 ,,	6,194 lbs.
At the time the seed is ripe	19,057 ,,	3,811 ,,
Aftermath	6,806 ,,	—

Vianne obtained a yield of 6,950 lbs. of hay per acre, from a fertile loamy sand.

Nutritive value.

The grass is not readily eaten by cattle, because of the fine covering of hairs. Sir Humphrey Davy recommended sprinkling with salt, in order to make the hairs moist and limp, and thus render the grass more palatable. Before using, its hay should always be finely chopped, and mixed with other fodder. 100 lbs. of hay contain 79.5 % of organic matter composed of: —

Albumin (N × 6.25)	9.0 lbs.
Fibre	36.5 ,,
Non-nitrogenous extractives	31.6 ,,
Fat	2.4 ,,

Compared with other grasses, the proportion of albumin is small. As yet the proportions of digestible, nutritive material have not been determined, but in any case, the amounts must be small, since the plant is so hairy. It may be taken as a general rule, that any fodder which is not liked by stock is more difficult to digest than another which is more readily eaten.

Harvesting the seed.

Harvesting, Impurities and Adulteration of seed. Commercial seed of *Holcus* is usually merely the cleanings of Perennial rye-grass. In Scotland, where *Holcus* is a frequent impurity of rye-grass, its seed is separated, after threshing, by the winnowers. In this way a number of empty rye-grass pales pass over with it; therefore the seed of *Holcus* has only 30 to 40 % purity; the rest of the seed consists chiefly of chaff of Perennial rye-grass. Some commercial seed is obtained from Germany. There, it is collected from the wild plant, in wood-clearings and the like. Cultivation for seed-production is not profitable, for, although the collection is easy, the price which the seed fetches, is very low.

Yield.

Werner gives the average yield of seed as about 100 lbs. per acre.

Impurities.

The most common impurity, next to Perennial rye-grass, is Soft Brome *(Bromus mollis* fig. 23). A small proportion of Woodrush *(Luzula)* and other weeds may also occur.

Adulterations.

The price being low, adulterations are not attempted. At times the seed of Creeping soft-grass *(Holcus mollis* fig. 24) is met with, but that is a natural impurity, and no adulteration. Being cheap, »Yorkshire fog« is often used either for adulterating dearer grasses, e. g. Meadow foxtail (which see), or to form a main constituent of the »prepared mixtures« of the seedsman.

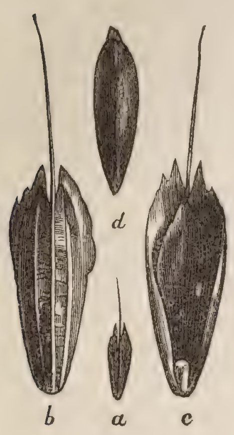

Fig. 23.
Soft Brome, *Bromus mollis.* L.
a. False fruit, natural size.
b. the same, magnified, dorsal surface.
c. the same, magnified, ventral surface.
d. caryopsis, magnified (after Nobbe)

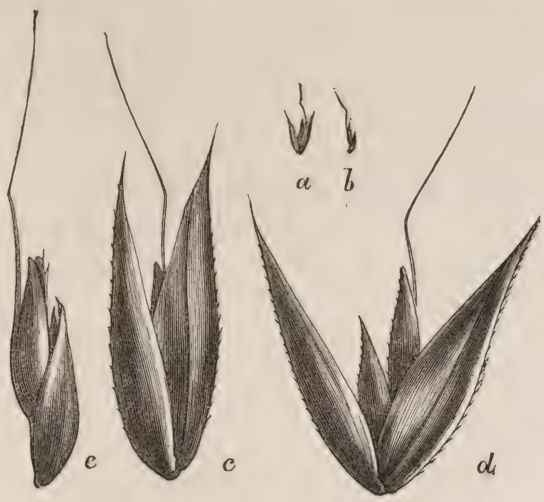

Fig. 24.
Holcus mollis, L.
a. and *b.* spikelets, natural size.
c. and *d.* spikelets × 7.
e. spikelet without the glumes × 7.

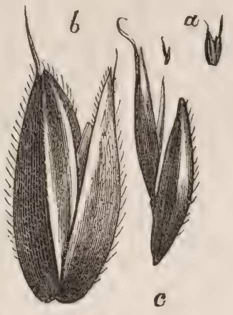

Fig. 25.
Yorkshire fog, *Holcus lanatus,* L.
a. False fruit (spikelet) natural size.
b. the same, enlarged.
c. spikelet without the glumes (after Nobbe).

Seed quality.

Seed and Amounts to be sown. The average purity is 68.2 %, and the germinating power 34 %. German seed is usually purer than Scotch, although the impurities of Scotch seed are usually of a more harmless nature (chaff of Perennial rye-grass) or even useful constituents (Perennial rye-grass). German seed frequently contains very many weeds. Prime seed should have 80 % purity, and 50 % germination = 40 % of pure and germinating seed. The spikelets usually constitute the commercial seed. 1 lb. of pure seed contains 1,304,000 grains; rarely however are the glumes removed (fig. 25 c.). The weight per bushel is 6½ lbs.

Amount to be sown.

1 acre of ground requires 22 lbs. of seed containing 40 % pure and germinating = 8.8 lbs. of pure and germinating seed.

Mixtures.

It should only be used in mixtures on an appropriate soil, either with clover, or for temporary or permanent grass-lands. On peat or a dry sand, as much as 30 % may be used. On better land the proportion, if any, should be very low; the best plan is to leave it out altogether.

VIII. Timothy or Meadow Cats-tail.

Phleum pratense, L.

Explanation of plate.

Fig. A. Entire plant in flower, shewing two spikes in flower, and a young spike.
,, 1. Spikelet before flowering; when in fruit the spikelet is quite similar.
,, 2. Spikelet in flower, shewing the stamens and stigmas protruding from its apex.
,, 3. The flower enclosed in the pales.
,, 4. The flower detached; composed of 2 lodicules, 3 stamens, and a pistil.
,, 5. False fruit, side-view *i. e.* the caryopsis enclosed in the pales.
,, 6. False fruit, ventral surface.
,, 7. The caryopsis.
,, 8. Diagram of the one-flowered spikelet.
,, 9. Portion of the culm, with leaf-sheath, blade, and ligule.
,, 10. Transverse section of a leaf-blade (after Lund), shewing the indistinct ribs.

Botanical description.

Timothy forms simple, somewhat compact *tufts* of grass. The *branches* are intravaginal, but they soon burst the enclosing sheaths. No stolons are developed. The old sheaths of the radical leaves, break up into fibres (fig. A). The *culms* are smooth and erect; sometimes slightly bent at the base and rooting at the nodes. On dry ground, the base of the culm may thicken, (see varieties), and become tuberous. The *leaf-blades* are convolute in the bud, yellowish green in colour, rough on the margins, and very slightly ribbed on the upper surface (fig. 10). The *ligule* on the culm leaves is moderately long and acute (fig. 9); on the radical leaves it becomes shorter. The *inflorescence* is a compact spike-like panicle, in this case, a cylindrical spike, usually $1^{1}/_{2}$ — $2^{1}/_{2}$ inches long; on very rich soils 7—10 inches. The *spikelets* are one-flowered (fig. 8). The *glumes* (figs. 1, 2, 8) are equal, and do not cohere together (distinction from Fox-tail). They completely cover the pales, are laterally compressed, acutely keeled, and obtuse at the apex; the keel is provided with a row of stiff bristle-like hairs; its prolongation forms a short, stiff, apical awn. The *pales* are only half as long as the glumes. The *lower* (figs. 3, 5, 6, 8) is five-ribbed, obtuse, and awnless; at times, the midrib is prolonged into a very short awn (fig. 5). The *upper pale* has two keels (figs. 3, 5, 6, 8). The *lodicules* are two, very small, and slightly toothed at the apex (fig. 4). The *pistil* is composed of a glabrous ovary, a pair of long styles, and a pair of feathery stigmas (fig. 4).

During *flowering*, the glumes and pales remain closed, and the stamens and stigmas protrude from the apex of the spikelet (fig. 2). *Fertilization* is attained as in Perennial rye-grass. The *False fruit* (figs. 5, 6) is very small, somewhat ovate, closely invested by the pales, which are indurated, smooth and shining, of a silver grey colour, and very minute. The average length is $1^{1}/_{2}$ mm. The *caryopsis* freed from the pales, is roundish, acute at the base, and finely dotted on the surface (fig. 7). The *embryo* is darker in colour, and lies at the side of the acute base (fig. 7).

Name and History.

The scientific name, translated from the Latin, means »Meadow Cats-tail«. It was called »Timothy« after *Timothy Hansen*, who, in the middle of last century, cultivated it first in Carolina, and later, in Virginia. In 1760, *Peter Wynch*, president of the Agricultural Society of England, obtained the seed of this species, along with that of several other grasses, from North America. It soon came into general cultivation in England. In 1765, it was recommended in the »*Annual Register*« and the »*Museum Rusticum*« as deserving of more extensive cultivation. Soon after, it was brought into notice on the continent, by the Agricultural Societies there. In America it was called at first »Herd-grass«, but in Europe it was always known as »Timothy«. It is sometimes called »Cats-tail«, in reference to the tail-like, cylindrical spike.

Agricultural value.

Timothy is to-day one of the most extensively cultivated grasses, not only in Great Britain and on the continent, but also in the United States of America. It is either sown pure, or in mixture with Red clover. Year by year, its cultivation is extending. On heavy, cold, and wet clays, its place can be taken by no other grass. The seed is very cheap, and easily sown, so that Timothy can be laid down at a minimum cost. It is also useful for suppressing moss. It is not, however, without drawbacks — it is somewhat late, and readily becomes hard.

Varieties.

Varieties. »*Bulbous Cats-tail*« (Phleum nodosum, L.) is a variety very common on dry ground. It is distinguished by the tuberous swelling at the base of the culms. This is not a true variety, but rather an adaptation to a dry soil: — in moist ground no tuber is formed. Two other varieties are known: — 1. with the awn longer, and 2. with the awn shorter, than in the typical form. These latter varieties are, from an agricultural standpoint, equivalent to the type.

Geographical distribution.

Occurrence, Climate, Soil, Manure. This grass is indigenous to England, but as it had escaped the notice of agriculturists, the seed was at first imported from N. America. It is indigenous — to the whole of *Europe* except Arctic Russia, Greece, and a large portion of Turkey; to *Africa,* in Algiers; to *Asia,* in Caucasus, Georgia, Talusche, Siberia (Ural, Altai, Baikal); to *N. America,* in Newfoundland, Saskatchewan and Vancouver Island. Extends over the whole United Kingdom, but is perhaps introduced in the Shetland and Orkney islands, the Hebrides and northern Scotland. In Ireland, it is not abundant.

Habitat.

It occurs wild by the sides of roads, ditches, fields and on meadows and pastures, extending to Alpine regions.

Limits of altitude.

In England, it reaches an altitude of 1,150 ft., in Auvergne, 3,300—3,900 ft., in Upper Engadine, 5,600 ft., in the Pyrennees, 7,900 ft., in southern Spain, 6,800—10,000 ft., in Caucasus, 2600—5250 ft., and at Kasbek, 9500 ft. In Scotland it ascends to 1000 feet.

Climate.

Although better adapted for moist or humid soils, it withstands drought very well. In dry soils, however, the spikes and leaves become somewhat stunted, and the yield much reduced. It withstands a rigorous winter much better than most other grasses; consequently it is very useful on soils on which other cultivated plants are liable to be destroyed by cold.

Soil.

Timothy succeeds best on moist loams and clays. It is of the greatest value, on drained moors, as well as on cold, wet clays. It is precarious on sour soils, or on those which are scorched, shallow, and calcareous. It is often cultivated on loamy sands in Northern Germany, as a pasture and hay grass.

Substances removed from the soil.

1000 lbs. of hay remove from the soil: —

Nitrogen . . .	15.5 lbs.	Lime . . .	4.7 lbs.
Phosphoric acid	6.9 „	Magnesia . .	1.9 „
Potash . . .	20.4 „	Sulphuric acid	1.7 „
Soda	1.1 „	Silica . . .	18.9 „

Manure.

Experiment has proved, that the produce of Timothy is much increased by appropriate manure. *Heinrich,* for example, has shown, that, on a light, poor, sandy soil, sulphate of potash produces a comparatively high yield. Liquid manure and irrigation are also appropriate.

Growth.

Growth, Yield, Nutritive value. Timothy forms moderately compact tufts, and so, by itself, only forms a thin grassy cover for the ground. It is in general late: the spikes only protruding from the leaf-sheaths about the end of June, and flowering commencing in July. Nevertheless a mixture of Timothy with other grasses, or with clovers cut at the ordinary time, gives a large yield, since the hay is very heavy. Timothy hay is, in fact, heavier than that of any other grass, and contains a large quantity of nutritive matter in a small bulk. A cubic yard of its hay weighs from 600—850 lbs.

Harvest. It ought always to be cut before flowering, and before all the spikes have appeared; otherwise, it becomes very woody, and the hay is hard. The aftermath is usually less in quantity than the first cutting.

Yield. The amount of produce depends largely upon the nature of the soil, the manure, and the amount of moisture present. *Sinclair* obtained from a clay loam, the following produce, per acre: —

	Green.	Dry.
About the middle of April . . .	5,445 lbs.	—
On flowering	40,837 „	17,356 lbs.
At the time the seed was ripe .	40,837 „	19,398 „
Aftermath	9,529 „	—

Vianne gives the yield of hay as 5280—13,200 lbs. per acre. From a sandy soil, *Werner* obtained 5280—6160 lbs., and from a good soil at Grignon 5,280 lbs. *Sprengel* gives 3520—4400 lbs. of hay per acre. *Pinkert* obtained, from a shallow sandy loam, resting on a wet subsoil, 4050 lbs. in the second year.

Nutritive value. Timothy, whether by itself, or forming a large proportion of a clover mixture, makes an excellent green fodder. Its hay, although cut quite early, always becomes somewhat hard when dry. It is, however, much esteemed as horse fodder. Hay containing 10 to 20 % of Timothy, has no disagreeable taste, and does not lose in quality by drying. 100 lbs. of grass give, according to *Stebler* 32.4 lbs. of hay (containing 14 % of water); according to Wolff, 34.9 lbs. of hay. The hay contains, according to Wolff, 81.2 % of organic matter, composed of: —

Albumin (N × 6.25) . .	9.7 %	portion assimilated	5.8 %
Fibre	22.7 %	„ „	43.4 %
Non-nitrogenous extractives	45.8 %		
Fat	3.0 %	„ „	1.4 %

Ratio of nitrogenous to non-nitrogenous nutriment 1 : 8.

From analyses made in the laboratory at Zurich, Timothy contains in the first year of its growth: —

	Green.	Hay.	Without water.
Dry substance	27.84 %	86.00 %	100 %
Ash	2.17 %	6.70 %	7.79 %
Albumin (N × 6.25) . .	1.90 %	5.88 %	6.84 %
Fibre	9.69 %	29.93 %	34.82 %
Non-nitrogenous extractives	13.25 %	40.94 %	47.58 %
Fat	0.83 %	2.55 %	2.97 %

(Non-albuminoid nitrogen = 0.323 % of the dry matter.)

From these analyses it is seen, that the proportion of albumin is lower, and that of extractives (sugar, starch etc.), higher than in other fodder-plants. By itself, then, it is not a profitable fodder; it is best mixed with clovers or other plants rich in albumin.

Harvesting the seed. **Harvesting, Impurities and Adulterations of seed.** Timothy seed is easily harvested. For this purpose a pure crop is sown, and cut when the spikes begin to assume a yellowish-red tinge. At that time, only exceptionally early spikes allow spikelets to fall away. It should be mown on a sunny day, with a corn-scythe. It is allowed to dry for 2 or 3 days: or, in the evening, it is bound into small sheaves, which are arranged in stooks, and, according to the weather, left for four or five days in the field to become ripe. In stook, the seed is little injured by rain. When the sheaves are dry, they are taken to the barn, and threshed during winter.

Although Timothy seed is so small in size, still the amount produced is large.

Yield of seed.

In favourable cases, Pinkert obtained 700—880 lbs. of seed per acre. Werner gives 260—700 lbs. The price is always low, usually about 4d. per lb. *Sprengel* remarks, that it can be used for making a kind of meal, which is as good as that made from *Glyceria fluitans,* K.

In Silesia, seed is separated from a mixture with Red clover. Separation is very easy since Timothy-seed is very small, and detaches much more readily than that of Red clover. When cereals follow Timothy, the fodder-grass remains in part between the furrows, and grows up with the cereal, especially if the ground has been little tilled. Because of this, older writers regarded it as a weed. Among the cereals it vegetates luxuriantly, and sends up tall culms with long spikes, very rich in seed. In the case of winter-wheat, it is easy to obtain Timothy seed as an acessory product, because both ripen together. The seeds can readily be separated by sieves having a mesh of 1—1½ mm. Pinkert obtained in this way, a minimum of 88 lbs. per acre.

Commercial seed.

Timothy seed comes principally from N. America, also from Eastern Germany, and Austria. There is no sufficient experimental evidence to show whether American or European seed succeeds best with us: — in the experimental field at Zurich, no difference was noticed. American seed is usually purer than European, which often contains 10 to 20 % of impurity, and at times, even more. A part of this impurity consists of the small seeds of weeds. Timothy seed exported from Breslau, for example, often contains a large percentage of the seeds of — Corn Chamomile *(Anthemis arvensis),* Bladder Campion *(Silene inflata),* Chickweed *(Cerastium triviale),* Corn Spurry *(Spergula arvensis),* Forget-me-not *(Myosotis intermedia),* Plantain *(Plantago lanceolata),* Sorrel *(Rumex Acetosella),* Self-heal *(Prunella vulgaris),* Sand-wort *(Arenaria serpyllifolia),* Ox-eye daisy *(Chrysanthemum Leucanthemum),* and Dodder *(Cuscuta Trifolii).* When Timothy seed is separated from a mixture with Red Clover, the small seeds of the clover Dodder, if present, come through the sieves along with the Timothy seed. It is true that Dodder does not attack Timothy; but if such Timothy seed is sown along with clover, the Dodder attacks the latter. In purchasing seed to mix with clover, it is very necessary, therefore, to take care that the Timothy as well as the clover contains no Dodder seed. So far as we know, American Timothy seed never contains Dodder.

Impurities.

Adulterations.

Being cheap, this seed is rarely adulterated. At times grey sand is mixed with it. By superficial examination, this adulteration is readily overlooked, since Timothy seed has the same colour as the sand; on close inspection, however, the fraud is at once detected.

Seed quality.

Seed amounts to be sown. Commercial seed usually consists of the caryopsis enclosed within the pales (figs. 5 and 6). When the seed is well ripened, or if it has been strongly threshed, the pales detach, and a large part of the seed is naked (fig. 7). Good, fresh, seed is recognised by the greyish-white, almost silvery tint of the pales; dark grey pales indicate that the seed has been injured by rain. Analyses of 170 samples, extending from 1876 to 1882, showed an average purity of 96.6 %, and a germinating power of 85 %. 1 lb. of pure seed contains 1,170,500 grains. American seed is usually smaller than German. A bushel weighs on an average 48 lbs. Good commercial seed should have 97 % purity and 90 % germination = 87.3 % of pure and germinating seed.

Amounts to be sown per acre. An acre requires, on an average, 16 lbs. of seed containing 87.3 % pure and germinating = nearly 14 lbs. of pure and germinating seed. Being small, it is easily sown by the clover-drill.

Mixtures. Timothy is only sown in mixtures with other grasses and clovers, either for a permanent or temporary ley. It is advantageously used either with Red or Alsike clovers. In England, it is customary to use in such mixtures 2—3$^1/_2$ lbs. of Timothy seed, per acre. For temporary grass-land, 5 to 20 % of Timothy is used, according to the nature of the soil. For permanent pastures, 10 % should not be exceeded, because in the third and fourth years, it usually becomes thin. Its deep root system specially fits it for deeply ploughed soils; otherwise its requirements are the same as those of other grasses with small seeds. The seed should be sown superficially. On damp ground, or moist, stiff, soils heavy rolling is advantageous.

Diseases. Timothy is at times attacked by a parasitic fungus *(Epicloe typhina,* Tul.). This fungus covers the sheath of the upper leaf with a thick coat of mycelium. At first this coating is greyish white, but later it becomes yellow. Where this disease is common, *Julius Kühn* recommends early cutting and then depasturing by sheep.

Distinction from Meadow foxtail. Timothy and Foxtail are externally very similar, and the similarity has led to great confusion regarding their agricultural properties; this is unfortunate, as Meadow foxtail and Timothy have quite different purposes to serve in agriculture. These grasses can most readily be distinguished by their spikelets (compare plate VIII, fig. 1 and plate IX, fig. 4). When growing in the field, Foxtail developes much earlier than Timothy.

IX. Meadow foxtail.

Alopecurus pratensis, L.

Explanation of plate.

Fig. A. Three spikes in flower, with their culms.
,, B. Base of a plant, shewing the short stolons bearing scales and roots, and the extravaginal buds.
,, 1. The spikelet in flower; the 3 stamens, 2 stigmas and an awn protrude from its apex.
,, 2. The same with the glumes and stamens removed, shewing the lower pale surrounding the flower, and the almost basal awn, which is at this stage straight.
,, 3. A flower detached, with the stamens cut off, shewing the pistil: there are no lodicules.
,, 4. The false fruit *i. e.* a spikelet, shewing the long hair on the keels and lateral ribs, the cohesion of the glumes, and the awn now bent.
,, 5. The same with the glumes removed. The caryopsis is seen shining through the membranous pale.
,, 6. The caryopsis, side-view.
,, 7. The same, transverse section.
,, 8. Diagram of the flat, one-flowered spikelet. The dotted lines indicate cohesion of the glumes.
,, 9. The ligule.
,, 10. Transverse section of leaf-blade (after Lund) shewing the low, broad, flat ribs.

Botanical description.

Botanical description. Meadow foxtail is, to a large extent, a *stoloniferous* grass. The *branches* are extravaginal; they run horizontally underground for a short distance, forming *stolons* with scale leaves (fig. B.). The terminal portions of the branches ascend into the air, as aerial branches with green foliage; these stand separate from one another. At times, several branches may ascend directly into the air without forming stolons; these, being close together, appear somewhat tufted. The *sheaths* of the radical leaves are at first white; later, they become brown, but never split up into fibres (fig. B). The *culm* is 2—3 ft. high, often bent and rooting at the basal nodes. The *leaf-blades* are convolute in the bud, very long, and somewhat rough; the ribs on the upper surface are flat and distinct (fig. 10). The *leaf-sheaths* are smooth, and usually slightly swollen on the culms. The *ligule* is long and obtuse (fig. 9). The *inflorescence* is apparently a cylindrical spike (fig. A). When closely examined, however, it is seen to be a branched inflorescence, each branch bearing 4 to 10 spikelets, and so in reality it is a spike-like panicle. As the branches and the pedicles are very minute, the resemblance to the spike is very strong. The *spikelet* is one-flowered and flat (fig. 8). Both *glumes* are equal, lanceolate, acutely keeled (fig. 8), and longer than the pale; the keel and lateral ribs have long soft hair (fig. 1). At the base, the glumes cohere for a third of their whole length (fig. 1). The *lower pale* is membranous; at the base, it spreads round the flower, and the margins unite; the awn, which is about twice as long as the pale, arises near the base (fig. 2). The *upper pale* and the *lodicules* are absent. The *flower* is composed of three stamens and a pistil (fig. 3). The *anthers* are at first yellow; later, brown or violet. The *ovary* is glabrous; the *styles* are two, coherent beneath, and prolonged to form a pair of long feathery *stigmas* (fig. 3).

During *flowering*, the glumes and the pales retain their position (fig. 1). As in Timothy, a slight opening at the summit allows the anthers and the stigmas to protrude there. As is usually the case with grasses, self-fertilization is here impossible, because the anthers are protruded and bent away from the stigmas before they dehisce (fig. 1). At maturity, the whole spikelet forms the *false fruit:* it is known to be in fruit by the awn, which then becomes twisted and bent as in figs. 4 and 5. (Compare figs. 1 and 2). Including the awn, the spikelet is 8 mm. long, without it, 5 mm. The yellow *caryopsis* is flat and ovate, 2—$2^{1}/_{2}$ mm. long (fig. 7); at its base on one of the edges lies the embryo (figs. 6 and 7).

Name and History.

The English name Meadow foxtail is merely a translation of the Latin. Although long ago recommended by Linnæus, its cultivation has only recently commenced.

Agricultural value.

For leys of several years, or for permanence this is one of the most valuable »top« grasses; it is perennial, and produces abundance of good fodder.

Geographical distribution.

Occurrence, Climate, Soil, Manure. Meadow foxtail is indigenous — to almost all *Europe*, even Lapland; to *Northern Africa*, to *Asia*, in Caucasus, Georgia, Siberia (Altai, Baikal, Dahuria).

Habitat and Limits of altitude.

It frequently occurs on grass-land which is moist, rich in humus and deep, in valleys, and on alluvial soils. On the Alps, it occurs at a height of 5,250 ft.

Climate.

No fodder-grass withstands cold so well as this; late frosts do it no great injury. Consequently in an extreme season, it suffers comparatively little. It can grow well in the shade and is thus appropriate beneath trees. Its growth commences quite early, when the trees are still in bud, before the leaves are out to intercept the light. At this time, the light has free access and gives the grass a good start.

Soil.

Poor dry soils are not suitable. In such, it remains small, and after a short existence disappears altogether. It succeeds best on loams and clays rich in humus, on moist loamy sands, and on all good soils containing humus. It is a good grass for very moist soils, or for irrigated lands. It cannot bear stagnant water.

Substances removed from the soil.

1000 lbs. of hay remove from the soil: —

Nitrogen . .	16.6 lbs.	Magnesia . .	0.9 lbs.
Phosphoric acid	4.2 „	Sulphuric acid	1.5 „
Potash . . .	28.9 „	Silica . . .	26.0 „
Lime	2.6 „		

Manure.

The application of manure, whether liquid, farmyard, compost or artificial, is very advantageous and profitable.

Growth. Development.

Growth, Yield, Nutritive value. Meadow foxtail forms short underground stolons, but no tuft: hence the grass it produces is thin. This and sweet-scented vernal are the earliest fodder-grasses. In early seasons, the long sappy leaves are out by the beginning of April; by the middle of the month, the first spikes are appearing; by May, the grass is in flower; and soon after, the seeds are ripe. The second cutting yields, like the first, culms and abundance of leaves about 16 inches long. From a good soil, three cuttings may readily be taken. The produce is small in the year of sowing, good in the second, and reaches its maximum in the third.

Yield.

Sinclair obtained, from a good clay loam, the following yield, per acre: —

		Green.	Dry.
1st cutting	1st June	20,419 lbs.	6,126 lbs.
2nd ,,	1st Sept.	8,167 ,,	—
	Total	28,586 lbs.	6,126 lbs.

Vianne obtained from a fertile loam: —

		Green.	Hay.
1st cutting	1st June	19,050 lbs.	6,072 lbs.
2nd ,,	1st Sept.	8,976 ,,	2,860 ,,
	Total	28,026 lbs.	8,932 lbs.

Nutritive value.

The following analyses show the nutritive value: —

	Grass.		Hay.		Dry Substance.	
	1st Cut. in flower.	2nd Cut. leafy shoots.	1st Cut. in flower.	2nd Cut. leafy shoots.	1st Cut. in flower.	2nd Cut. leafy shoots.
Water	73.38 %	75.66 %	14.00 %	14.00 %	—	—
Ash	3.31 %	2.23 %	10.65 %	7.89 %	12.39 %	9.18 %
Albumin (N × 6.25) . .	2.13 %	3.08 %	6.86 %	10.88 %	7.98 %	12.65 %
Fibre	8.62 %	7.97 %	27.77 %	28.16 %	32.30 %	32.74 %
Non-nitrogenous extractives	12.08 %	9.99 %	39.19 %	35.28 %	45.55 %	41.02 %
Fat	0.48 %	1.07 %	1.53 %	3.79 %	1.78 %	4.41 %

Non-albuminoid nitrogen in the dry substance: — 1st cutting 0.154 %, 2nd cutting 0.103 %. According to older analyses the following is the composition: —

	Grass in flower.		Hay.	
	Ritthausen and Scheven.	Way.	Ritthausen and Scheven.	Way.
Water	66.8 %	80.2 %	14.0 %	14.8 %
Ash	2.1 %	1.5 %	5.4 %	6.6 %
Albumin	2.7 %	2.4 %	7.0 %	10.6 %
Fibre	15.5 %	6.7 %	40.1 %	29.0 %
Non-nitrogenous extractives	12.1 %	8.7 %	31.4 %	37.0 %
Fat	0.8 %	0.5 %	2.1 %	2.5 %

The nutritive matters are thus seen to occur in good proportion. The fodder has a sweet taste, and whether green or dry, is readily eaten. In wet weather it is readily laid, and liable to become rotten at the bottom. To prevent this it should be mown frequently.

Harvesting the seed.

Harvesting, Impurities, and Adulteration of Seed. Seed becomes ripe soon after flowering. Seed-harvesting is difficult because the spikes ripen so very unequally. At hay-time, many of the seeds are ripe, and, if this grass is abundant in the meadow, the farmer should then collect his seed. At Zurich, on the 5th June *i. e.* at hay-time, 225 spikes of Meadow foxtail were cut, made into a sheaf, taken home, and dried. Two months after, $^{1}/_{8}$oz. of heavy seed was shaken out; the germination of this seed was 52 %, a very high result for Foxtail. Five weeks later an additional $^{1}/_{4}$oz. of seed was shaken out; the germination of this was 45 %. The remaining seed $^{2}/_{3}$oz. was stripped off: of this only 9 % germinated. 225 spikes thus yielded: —

	Weight.	Germination.
by 1st operation	$^{1}/_{8}$	52 %
2nd ,,	$^{1}/_{4}$	45 %
3rd ,,	$^{2}/_{3}$	9 %

Total $1^{1}/_{24}$oz. Average germination 23 %.

Although the 3rd lot of seed was of low quality the first two lots were good. The first seeds were heaviest, largest, and germinated best.

400 seeds of the 1st lot weighed	0.375 gram
,, ,, ,, .. 2nd ,, ,,	0.265 ,,
,, ,, ,, ,, 3rd ,, ,,	0.108 ,,

By following this plan many farmers could easily obtain good seed of this valuable grass. Cutting the culms has this advantage, that the seed can be allowed to mature, whereas, if stripped from the spikes, maturation cannot go on. If, in the experiment mentioned above, the seeds had been stripped off by hand, and then allowed to dry, the germination would have been much lower. In harvesting this seed, it is of the utmost importance to arrange matters so that perfect maturity may be reached. Ripening commences at the apex of the spike, and gradually proceeds towards the base, i. e. the upper seeds are ripe before the lower. To obtain Meadow foxtail seed on a large scale, the grass is sown by itself. When ripe, the tops of the culms are cut off, brought home, and allowed to ripen in a dry airy place. When well dried, the seed is threshed out. By graduating the force of the threshing, various qualities of seed may be obtained. Stripping, for a seed-harvest, should be commenced when the spikelets are turning brown and beginning to fall away from the spike. Cutting, for seed, is begun somewhat earlier, to prevent loss. The first cutting is alone profitable for this purpose. Sprengel says: »The harvesting of ripe foxtail seed is very difficult. Each spike when yellow (ripe) must have its seed stripped off by hand. To prevent loss, and to obtain large produce, the grass should be grown in rows because the spikes ripen very unequally, and very readily allow the seed to fall away. The stripped seed should be spread out in a thin layer in an airy place, and left for 10 or 12 days; if not turned daily, the germinating power diminishes.«

Impurities and adulterations.

Seeds of *Holcus (lanatus* and *mollis)* are frequent impurities. These are often intentionally added, as they are very cheap, and externally somewhat similar to Meadow foxtail. *Holcus* is readily recognised by the glumes: — the hair is spare on the keels (fig. 26 and 27) but abundant in Foxtail (plate IX, fig. 1). When the glumes are removed, the recognition of *Holcus* is still easy: — then it always appears as a white, shining body, composed of a caryopsis covered by the adhering pales (fig. 27c); the caryopsis of Foxtail falls out of the pale and is yellow. Slender foxtail *(Alopecurus agrestis,* L.) is a common weed which is often used as an adulterant. Its seed differs from that of Meadow foxtail in the following points: — it is darker, heavier, not so strongly flattened, and firmer; one surface is convex, the other, concave; *the margins* (keels) *have only a few stiff hairs,* instead of abundant long soft hair; the glumes are united for half their length. *Melica ciliata* L. (fig. 28) is a rare adulterant readily known by its very long, white, silky hairs.

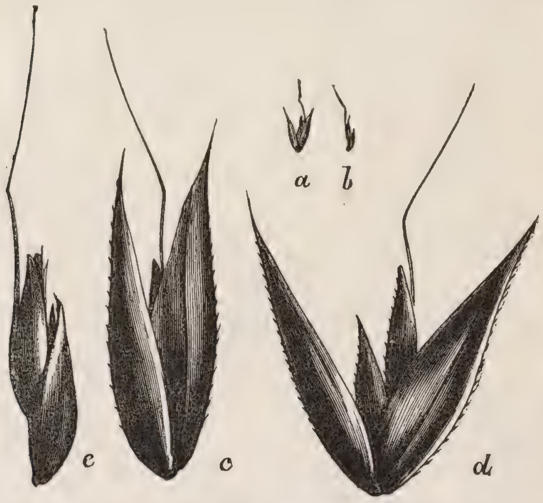

Fig. 26.
Creeping soft grass, *Holcus mollis*, L.
a. and *b.* spikelet in fruit, natural size.
c. and *d.* spikelet × 7,
e. the same, with the glumes removed × 7 (after Nobbe).

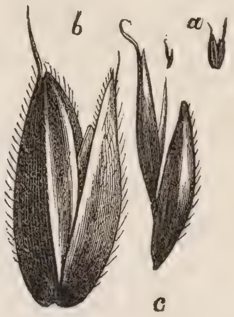

Fig. 27.
Yorkshire fog,
Holcus lanatus, L.
a. False fruit (spikelet), natural size.
b. the same × 7,
c. the same with the glumes removed × 7 (after Nobbe)

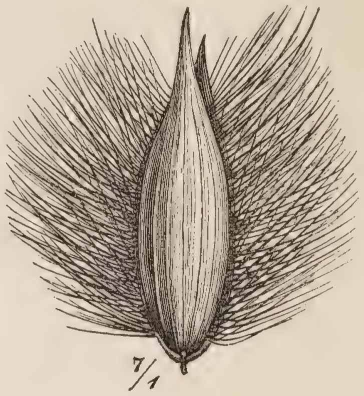

Fig. 28.
Melica ciliata, L.
False fruit.

Seed quality.

Seed and Amounts to be sown. The seed of commerce has frequently low germinating power, because it is often gathered before it is ripe. Seed with high germination is rare, so much so that a germination of 30 % may be reckoned good; qualities with less germinating power are very common. The average germinating power of 79 samples analysed was 19 %, and the average purity 78.7 %. Good seed should have 90 % purity. 1 lb. of pure seed contains about 907,000 grains; a bushel weighs on an average 6 lbs.

Amount of seed to be sown.
Mixtures.

An acre of ground requires 23 lbs. of seed containing 27 % pure and germinating = 6.21 lbs. of pure and germinating seed. Foxtail is never sown by itself, but is always mixed with other grasses and with clovers, because it gives a full yield only in the second or third year. A mixture with Meadow fescue, Cocksfoot, Perennial rye-grass, False oat-grass and Alsike Clover, is appropriate for a ley extending over three or more years. Foxtail should also find a place in all mixtures for permanent pastures.

X. Sweet-scented vernal grass.

Anthoxanthum odoratum, L.

Explanation of plate.

Fig. A. Five culms, in flower. From the apex of some spikelets the stigmas alone are protruded, from others two stamens and two stigmas.
„ B. The simple tuft of grass.
„ 1. A spikelet in flower. The anthers are open and lie above the stigmas, so that self-fertilization can occur.
„ 2. The same with the lower and upper glumes removed.

Fig. 3. The same at a later stage of flowering, with the inner glumes removed to shew the pales. The lower pale embraces the base of the flower. The filaments of the stamens have bent so that the anthers now lie below the stigmas, and the pollen can cross-fertilize other spikelets.

„ 4. The upper pale and a young flower with one of the stamens removed, shewing the pistil, and the stamen opposite the upper pale.

„ 5. A young flower, composed of two stamens and a pistil, but no lodicules.

„ 6. The false fruit (seed). The long awn of the inner pale is now bent and twisted (compare fig. 2).

„ 7. The same with the inner glumes removed, shewing the lower pale.

„ 8. The same with the lower pale removed; the part of the caryopsis to the right is covered by the upper pale, to the left it is bare.

„ 9. The same, but the upper pale removed, giving a side view of the caryopsis.

„ 10. The caryopsis from the dorsal surface.

„ 11. The long obtuse ligule of a culm leaf.

„ 12. Diagram of the cylindrical spikelet. Observe the ribs of the glumes, and the stamens opposite the pales.

„ 13. Transverse section of a leaf-blade (after Lund), shewing the low ribs.

Botanical description.

Botanical description. Sweet-scented vernal grass is perennial. The *branches* form a compact tuft of »bottom grass« (fig. B): they are either intravaginal, or, especially those which originate from the older parts, extravaginal. The rhizome is contracted and only rarely has elongated branches; the tuft is thus simple. The sheaths on the underground parts are colourless and very persistent. The *culms* are 12—18 inches high, erect, smooth, and naked beneath the panicle (fig. A). The *leaf-blades* are more or less hairy on the margins especially about the base, convolute in the bud (fig. B), afterwards flat and slightly ribbed on the upper surface (fig. 13). The *leaf-sheath* is smooth; the *ligule,* long and obtuse (fig. 11). The *inflorescence* is a cylindrical, spike-like panicle, oblong or somewhat ovate in form, and of a yellowish-green colour. At first, the spikelets are quite close together; later, they become somewhat spreading, and then the panicled nature of the inflorescence is more apparent (fig. A). The spikelet is one-flowered, cylindrical (fig. 12), ovate and acute (fig. 1). Each spikelet has four *glumes* arranged in pairs, the outer and the inner or barren glumes (fig. 12). *The outer glumes* cover and conceal the other parts of the spikelet; both are acute and almost glabrous; the lower is about half as long as the upper (fig. 1). The *inner* or *barren glumes* (figs. 2 and 6) are almost equal, slightly longer than the pales, rounded at the apex, and covered with long hair which is stiff, dark in colour, and shining; both barren glumes have dorsal awns, the one short, the other three times as long; during flowering (fig. 2) both awns are straight, but when in fruit (fig. 6) the long awn becomes bent and twisted, while the other remains straight. The *pales* (fig. 3) are a pair of membranes, shining, glabrous, and obtuse; the lower is somewhat orbicular, and almost covers the other; the upper (fig. 4) is ovate and shorter. There are only *two stamens,* and this is the only British grass which has only two; the position (fig. 12) is peculiar, one is placed opposite the upper pale (fig. 4), the other opposite the lower. The *pistil* (fig. 4) is composed of a glabrous ovary, terminated by a pair of long thread-like styles; two rows of short hairs spring from the terminal part of each style; these form the long, feathery stigmas (fig. 3).

During *flowering* (fig. 1) the apex of the spikelet opens slightly; the stigmas are protruded from the apex before the stamens. The behaviour of the anthers is peculiar: — while above the stigmas of their own flower, i. e. before the filaments are bent down (figs. 1 and 2), the anthers open and discharge part of their pollen upon the pair of stigmas lying immediately beneath them. This arrangement for securing self-fertilization is rare; cross-fertilization is the rule among grasses. Later on, the filaments become bent and the anthers are then lower than the stigmas belonging to the same flower (fig. 3). Now the normal process of cross-fertilization goes on: — the remainder of the pollen falls upon and fertilizes other flowers which lie beneath the anthers.

The *false fruit* (fig. 6) is composed of the caryopsis covered by the pales and inner glumes, i. e. the whole spikelet minus the outer glumes. This comes into commerce as Sweet-scented vernal grass seed. Its length including the awn is 6—7 mm., without the awn, 3—4 mm. Its surface, formed by the inner glumes is dark, hairy and awned. The *caryopsis* (figs. 9 and 10), seen when the inner glumes and the pales are removed, is smooth, glabrous, and slightly compressed at the sides.

Varieties.

Varieties. *Alefeld* distinguishes two varieties: — 1. Common sweet-scented vernal grass (*Anthoxanthum odoratum* var. *vulgare,* Alef.), 2. Hairy sweet-scented vernal grass *(Anthoxanthum odoratum* var. *pilosum,* Döll.). In the first variety both outer glumes are glabrous; in the second variety both are hairy, the upper on its whole surface, the lower on the keel and basal margins. The plate shews the common variety; the hairy variety is rare: both are of equal value to the agriculturist.

The generic name »Anthoxanthum« refers to the yellow colour of the spikelets.

Agricultural value.

Among fodder-grasses, this is only of secondary importance. It gives to hay a peculiar odour, due to the presence in it of a substance called *coumarin.* The same substance occurs in many other plants e. g. Reed canary grass *(Phalaris arundinacea),* Blue melilot *(Melilotus cœrulea),* Woodruff *(Asperula odorata),* Tonca bean *(Dipteris odorata),* etc. Because of this odour, its cultivation was strongly recommended, but, as *Hafener* properly points out, an odour agreeable to us is not necessarily so to domestic animals: besides, an herb is liked, less for its aroma, than for its taste. The taste of sweet-scented vernal grass is bitter*), and, like the odour, this is due to *coumarin;* that the taste is disagreeable is shewn by the fact, that whether fresh or dry, it is only eaten by cattle and sheep in cases of extreme hunger.

Sinclair says, »Mr. Grant of Leighton, laid down a field of considerable extent; one half of which was sown with this grass and white clover, the other half, with meadow foxtail and red clover. The sheep would not touch the sweet-scented vernal and white clover, but kept constantly on the foxtail grass, though the dwarfish nature of the sweet-scented vernal had occasioned an unusual degree of luxuriance of the white clover, with which it was combined. This would indicate that it is not, when single, or when combined with but two or three different species, very grateful to cattle.« When dry, other grasses give an agreeable odour, and it is thus an error to suppose that the odour of hay is entirely due to sweet-scented vernal. Almost every grass and every weed has, in a dry state, a specific odour, but from this, the value of the plant cannot at all be judged; certainly, when hay has a musty smell, the odour is a guide to its value, but no judgment can be formed from the presence of the odour of sweet-scented vernal. The underground parts contain more coumarin than the culms and leaves, and these are sometimes used for scenting snuff. Although sweet-scented vernal is a small plant yielding little produce, and as a fodder, neither valuable by itself, nor when forming a large percentage of a mixture; still, in dry soils and dry climates it is very important, because on its low, compact grass dew is formed and retained. In this way, it makes dry ground somewhat humid and more favourable for the growth of other and better grasses. It is said to have the property of suppressing moss. Worms and insects injurious to other plants do it no harm.

Geographical distribution.

Occurrence, Climate, Soil, Manure. Sweet-scented vernal grass is indigenous — to *Europe,* extending from Italy and the mountainous parts of Greece to Iceland and the North Cape, and from Portugal and Spain (where it is rare, and only occurs on the mountains) to the Urals: to *Africa,* in the Mediterranean region (except Egypt), and the Canary Islands; to *Asia,* in Caucasus and throughout Siberia. It has been introduced into *North America.*

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*) Sweet-scented vernal may readily be distinguished from other grasses by the bitter taste of its leaf.

Habitat.

It is very common on grass-land whether dry or wet, in woods, on hills, heaths, etc.

Limits of altitude.

On the Bernese Alps it attains an altitude of 6,250 ft. *(Rothenbach)*, and on the Grisons 7850 ft. *(Brügger)*. In the Caucasus it occurs between the limits of 5,900—9,200 ft. In the Lofodden Isles it ascends to 2,000 feet.

Climate and Soil.

This plant adapts itself to the most varied conditions of climate and season, and is little affected either by cold, moisture, or drought. *Roth* properly regards it as one of the shade-loving grasses, as it grows naturally, often in abundance, under the shade of other grasses, and in woods. It occurs on all kinds of grass-land, whether the soil is dry and light, or wet and heavy, and is to be met with even on moorland. It succeeds best on moist sands and loams; still, it is only advisable to sow Sweet-scented vernal on such soils, when they are too dry to allow the successful cultivation of better grasses.

Substances removed from the soil.

According to the analyses of Arendt, Way and Ogston, 1000 lbs. of hay remove from the soil:

Nitrogen	17.5 lbs.	Magnesia	1.2 lbs.
Phosphoric Acid . .	4.8 „	Lime	3.8 „
Potash	21.7 „	Silica	22.5 „
Soda	1.5 „	Sulphuric Acid . .	0.2 „

According to the Zurich analysis, the amount of Nitrogen during flowering is 1.083 %.

Manure.

This grass shows no preference for any kind of manure. In highly manured land it disappears and makes room for grasses and other plants of a more productive kind.

Growth.

Growth, Yield, Nutritive value. Sweet-scented vernal forms compact tufts of grass, and produces culms in such abundance that mowing is somewhat difficult.

Development.

After sowing, it developes more rapidly than other fodder-plants, so that even in the first year the yield is good. In spring, it is the earliest grass: on lands well exposed to the sun, the culms appear in March, flowering takes place in April, and by May the seed is ripe. Before hay-time, Sweet-scented vernal grass has already shed and sown its seed; in this way, by self-sowing, it spreads and multiplies extensively. By hay-time, the culms are as hard as straw, and the nutritive value, accordingly, low. This is a great disadvantage, and becomes more pronounced if the spring is early, or hay-time late. Its advantages are these: — it is very early, and so can thrive on soils of the driest types, as it has the spring moisture at its disposal; after each cutting, it rapidly sends up new shoots, and continues growing till autumn, but its produce then is not so luxuriant as at first.

Yield.

According to *Nickles*, 100 lbs. of grass, cut when in flower, give 28 lbs. of hay. According to *Sinclair* a brown, sandy loam, with manure, gives the following yield per acre: —

	Green.	Dry.
1st April	3,488 lbs.	—
On flowering	7,827 „	2,104 lbs.
At the time the seed is ripe .	6,126 „	1,838 „
Aftermath	6,806 „	—

Nutritive value.

The yield is thus comparatively poor. The nutritive value is also low as is shown by the following analyses. The grass analysed was cut when in flower on the 16th May, and the proportion of water was reckoned as 14 %.

Ash	5.1 %
Albumin (N × 6.25) . . .	6.8 %
Fibre	29.4 %
Non-nitrogenous extractives . .	43.0 %
Fat	1.8 %

(Non-albuminoid nitrogen 0.158 % of the dry matter).

Other analyses gave the following results: —

	Way.	Peters.	Collier.
Albumin	8.94 %	8.56 %	7.34 %
Fibre	31.17 %	22.10 %	22.10 %
Non-nitrogenous extractives	37.27 %	46.12 %	46.12 %
Fat	2.92 %	2.92 %	2.92 %

Seed-collection.

Impurities.

Adulteration.

Harvesting, Impurities and Adulteration of seed. The small quantity of genuine seed which occurs in commerce is usually collected in central Germany, from wild plants growing in the woods. Genuine seed is very dear, as its collection is very troublesome, and takes much time. Obtained in this way, the impurities will consist of the seeds of the wild plants growing along with it in the woods viz: — Woodrushes *(Luzula albida,* DC. and *campestris,* DC.), Sorrel *(Rumex acetosella,* L.), Sheep's fescue *(Festuca ovina,* L. var. *tenuifolia*), etc. At Lüneburg in Hanover, an annual grass, closely allied to Sweet-scented vernal, frequently occurs as a weed among the rye; — this is Puel's Vernal grass *(Anthoxanthum Puelii,* Lec. and Lam.). It covers the ground with a compact, felted vegetation, which is very difficult to cut. Before and during mowing, sufficient seed falls out to ensure a new crop; the remainder is separated from the rye, by means of sieves. These cleanings are sent into commerce as Sweet-scented vernal grass seed. A small district of 11 square miles, sends yearly to Hamburg 44,000 lbs. of the seed of *A. Puelii* to be sold as that of Sweet-scented vernal grass. Obtained in this fashion, Puel's Vernal grass seed usually contains the pointed seeds of rye which have come through the sieves, Silky bent-grass *(Apera spica-venti,* P. Beauv.) fig. 29, corn-flower *(Centaurea cyanus,* L.) fig. 30,

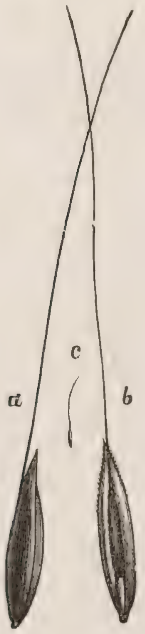

Fig. 29.
Silky bent grass,
Apera spica-venti, P. B.
False fruit (seed) with the awn.
a. side-view,
b. ventral surface × 7,
c. natural size.
(After Nobbe.)

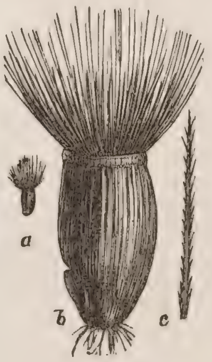

Fig. 30.
Cornflower.
Centaurea Cyanus, L.
a. and *b.* fruit with the pappus.
a. natural size.
b. × 7.
c. a hair of the pappus, highly magnified. (After Nobbe.)

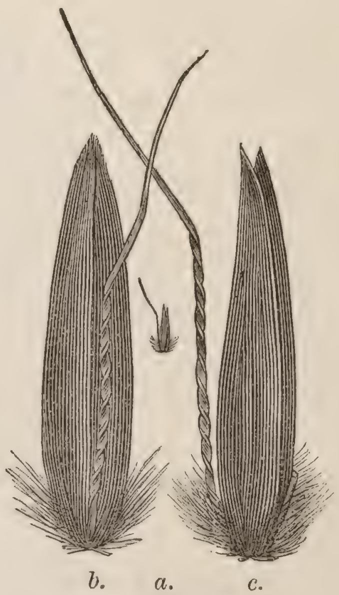

Fig. 31.
Wavy hair grass.
Aira flexuosa, L.
False fruit (seed)
a. natural size,
b. dorsal surface × 8,
c. side-view × 8.
(After Nobbe.)

Scleranthus annuus, etc. The seed of *Anthoxanthum Puelii* is not easily distinguished from that of *Anthoxanthum odoratum;* seen in mass, however, Puel's vernal grass appears lighter in colour; the glumes are, in general, slightly shorter. Being an annual, it is not only worthless, but actually injurious, in permanent mixtures; since, in the first year, it occupies the ground, and suppresses other grasses by its fine, felted tufts. Further, when used as fodder it cannot sow itself, and by the second year has disappeared. In pasture for a single year, a small proportion might be used, but it is of no use for mowing. Another seed used as an adulterant is Wavy hair-grass *(Aira flexuosa,* L.*)* fig. 31; this is easily recognised.

Seed quality.

Seed and amounts to be sown. Good seed should have an average purity of 85 % and 30 % germinating power = 25.5 % of pure and germinating seed. When kept, the germinating power slowly decreases. 1 lb. of pure seed contains on an average 924,000 grains. An acre of ground requires 30 lbs. of seed containing 26 % pure and germinating = 7.8 lbs. of pure and germinating seed. For fodder, sweet-scented vernal grass is never sown by itself, but always in mixture with other grasses. In temporary or permanent leys, it only plays the part of an aromatic grass.

Amount per acre.
Mixtures.

XI. Fiorin or Stoloniferous bent-grass.

Agrostis stolonifera, L. or *Agrostis alba,* Schrad.

Explanation of plate.

Fig. A. Part of a plant showing the stolons.
,, B. Panicle before flowering.
,, C. Panicle during flowering.
,, 1. Spikelet in flower, side-view.
,, 2. The same with the glumes removed.
,, 3. The lodicules and pistil.
,, 4. The spikelet, in fruit *i. e.* false fruit.
,, 5. The same with the glumes removed, side-view.
,, 6. The same, ventral surface.
,, 7. Caryopsis, dorsal surface.
,, 8. Caryopsis, ventral surface, shewing the groove.
,, 9. Diagram of the one-flowered spikelet. Observe the keeled glumes.
,, 10. The ligule, long and acute.
,, 11. Transverse section of a leaf-blade (after Lund), shewing the acute and prominent ribs.

Botanical description.

Botanical description. Fiorin sends out long *stolons* (fig. A) which may lie either above or beneath the ground. These root at the nodes and give off branches which are extravaginal, as they must be in all completely stoloniferous grasses. The *culm* is 8—30 inches high, smooth, erect or ascending, rarely bent and rooting at the base. The *leaf-sheaths* are smooth. The *ligule* (fig. 10) is long and acute (distinction from *Agrostis vulgaris,* Common bent, which has a short, obtuse ligule). The short *leaf-blade* is convolute in bud, afterwards flat, linear, acute, and rough from above downwards; the ribs are acute and prominent (fig. 11). The young *inflorescence* (fig. B) is a contracted panicle; its branches are arranged in tufts placed at equal but distant intervals along the axis of inflorescence; during flowering, they become horizontal and produce a spreading and somewhat ovate form of panicle (fig. 6); when flowering is over, the panicle again becomes contracted (distinction from *Agrostis vulgaris)*; the colour is white, tinged with red or violet. The *spikelet* is one-flowered (fig. 1). Both *glumes* are longer than the pales, acute, and membranous (fig. 1); each has a midrib (fig. 9) which forms the ciliated keel (fig. 1). Both *pales* (fig. 2) are white membranes; the lower, about twice as long as the other, three-ribbed, notched at the apex, and awnless, or at times with a short awn; the upper has the usual structure and is bicarinate (fig. 9). The *lodicules* (fig. 3) are two, ovate and acute. The *pistil* (fig. 3) is composed of a glabrous ovary, terminated by a pair of almost sessile feathery stigmas. *Flowering* goes on as in Perennial rye-grass. The *false fruit* (fig. 4) is the spikelet, consisting of the caryopsis invested by the pales and the glumes; when ripe it is 2—3 mm. long. The *caryopsis* itself (figs. 7 and 8) is readily freed from the pales, oblong, attenuated at the base, convex on its outer, and furrowed on its inner face.

Varieties.

Varieties. The commonest variety has greenish-white spikelets, and is called *Agrostis stolonifera* var. *alba*, Alefeld. In seed catalogues *Agrostis stolonifera* and *Agrostis capillaris*, Pollich, are often mentioned separately, although they are identical. The best variety is perhaps Giant Fiorin *(Agrostis stolonifera* var. *gigantea*, Koch.) in which the panicle is well developed and much branched. Other varieties have no agricultural importance.

Name.

Stoloniferous bent-grass is a translation of the Latin botanical name. It is also known as creeping-rooted bent, Marsh bent, White bent, Whitetop, etc.

History.

About 250 years ago, this grass was known in England as a good fodder-plant. According to *Werner*, it came into cultivation in 1761, but soon after went out of use. 50 years later it again came into notice under the new name of Fiorin. In Ireland about the beginning of this century, *Dr. Richardson* pointed out its merit, and on his recommendation it came to be extensively cultivated in Great Britain. In 1814, *M. de Conicht*, of Frederick Sound in the Island of Zealand, experimented on it and gave very favourable reports of his results. About 1840, the cultivation of Fiorin commenced on the continent, and the grass obtained very high repute there.

Agricultural value.

Although fiorin has not fulfilled the high expectations it promised, still, in certain circumstances, it is not without value. On light soils of a moist nature, it forms good »bottom grass« well adapted for pasture. It is perennial, provides good fodder late in the year and continues growing till winter. It is not suitable for alternate husbandry, because its long creeping stolons are difficult to get rid of; in such cases, it is to be regarded as a weed.

Geographical distribution.

Occurrence, Climate, Soil, Manure. Fiorin is indigenous — to Central, Eastern and Southern *Europe*, in Portugal, Spain, France, Iceland, Scandinavia at Alten Fiord, England, and Ireland; to *Africa*, in Algeria, Abyssinia, the Canary Islands and Cape Verd; to *Asia*, in Caucasus and Georgia: it is also indigenous to *North America*.

Habitat.

This grass is especially frequent on wet ground. It is also common on mountains where cloud and dew persist.

Limits of altitude.

The variety *Coarctata (Agrostis patula*, Gaud.) with the panicle short, contracted, and highly coloured is frequent on the Alps; it is sometimes met with at a height of 7,200 ft.

Climate.

Maritime and mountainous climates and rainy districts are most suitable for this grass; wherever the air is dry the yield becomes much reduced. Thus is happens, that in Britain, this grass is much more productive than in Germany and France. On dry ground, the culms produce fewer leaves and soon become hard. Winter cold does no injury. *Conicht*, for example, allowed a part of the grass to stand over winter, and cut it in spring; the quality of the grass was then as good as that obtained from the same field in autumn. In England it is often pastured as late as December.

Soil.

Fiorin succeeds best on light, moist or wet soils. On moist moors and clays, it also thrives well. On dry soils, especially on dry firm clays, it is quite out of place; in these circumstances the delicate roots cannot penetrate, and the stolons become lignified and short. Fiorin ought therefore to be sown only on moist soils, which are not too heavy. On heavy land which can be irrigated, it may also be cultivated.

Manures.

So far, no analyses have been made to determine the nature and quantity of mineral matter removed from the soil by this grass. Reasoning from the nature of the roots, which are superficial and sparse, it is evident that the surface layer of the soil should be soft and fertile, and that irrigation would be very appropriate.

Growth.

Growth, Yield, Nutritive value. Fiorin produces creeping stems or stolons 6—12 ft., and on favorable ground often 18 ft. long. However, as *Schwerz* has appropriately remarked, »we are not to expect that the hay produced will be 6, 12 or 18 ft. long«, as the stolons do not rise into the air but creep along the ground. Here and there, short erect branches are produced, which, when the plant is growing well, are provided with abundance of leaves; these form the crop. When the soil and season are dry, fewer roots are produced; whereas in moist situations the stolons, especially when trodden by cattle, produce many roots and grow to very great lengths. As growth goes on, Fiorin gradually forms compact, felted vegetation, very difficult to get rid of when the land is broken up.

Development.

Fiorin developes rapidly after sowing, and in the first year the produce is almost at its best. In spring it is a late grass, but when once started, growth continues till late in autumn and winter. Flowering is also late, never before the end of June. Flowering and culm-production continue till autumn.

Harvest.

Yield.

At the usual hay-time the amount of produce is small, and so, when Fiorin occurs in a hay-mixture, its main produce goes to the second cutting. It is one of the most suitable grasses for providing late pasturage. For mowing it is not so suitable, although in Ireland, as much as 14,080 lbs. of hay per acre have been obtained. In Germany *Pinkert* reckons 4400—8800 lbs. of hay per acre as fair produce. From a moist fertile soil, *Vianne* obtained 6,290 lbs. per acre. *Sinclair* obtained the following produce per acre, from a clay soil: —

	Green.	Dry.
At the time of flowering	17,696 lbs.	7,742 lbs.
Aftermath	2,722 ,,	—

Nutritive value.

On appropriate soil, Fiorin yields succulent fodder readily eaten by cattle; on a poor, dry soil, the produce is hard, sapless and disagreeable. No chemical analyses have been published. According to *Sprengel*, it is very nutritive and its value is highest about the end of autumn.

Harvesting the seed.

Harvesting, Impurities and Adulterations of seed. This grass is never grown specially for seed. In the forests of Germany where Fiorin is often very abundant, wild plants are cut for seed. The seed is ripe about August or September. When the seed is hard and easily rubbed out by hand harvest-time has come. The seeds do not readily fall away, so that there is little loss from this cause.

Impurities and adulterations.

Commercial seed is often largely composed of glumes; these are easily removed by winnowers. Common impurities and adulterants are Brown bent *(Agrostis canina,* L), Tufted hair-grass *(Aira cæspitosa,* L.), and Silky bent *(Apera spica-venti,* P. Beauv.). The seeds of Brown bent and Fiorin are readily distinguished: — in the former, the pales are firmer and darker in colour, and the lower has a long dorsal awn. The seed of Tufted hair-grass (fig. 32) is larger than Fiorin; the stalk and base are hairy; the awn is as long as the lower pale and springs from its base; in *Silky bent* (fig. 29, p. 64) the lower pale is covered with short hair; the awn is almost apical, and 3—5 times as long as the pale. Timothy seed and grains of sand often form a large proportion of commercial seed.

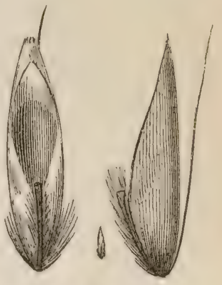

Fig. 32.
Tufted hair-grass.
Aira cæspitosa, L.
False fruit (seed);
a. natural size;
b. ventral surface;
c. side-view, × 8.

Seed quality.

Seed and amounts to be sown. In commercial seed, the naked caryopsis (figs. 7 and 8) rarely occurs; usually it is enveloped by the pales (fig. 5), and often by the glumes as well (fig. 4). On an average, the purity is 71.5 % and the germination 85 %. Good seed should have 85 % purity and 85 % germination = 72.3 % of pure and germinating seed. 1 lb. of pure seed contains 603,000 grains. The weight per bushel depends upon the number of glumes left with the seed. If all the glumes are left, the weight per bushel is small, scarcely 8 lbs.; but if the seed has been well winnowed, the weight may be 32 lbs. or more. When kept, the germinating power decreases very little, so that the seed generally germinates well. The purity of Fiorin seed is often less than it ought to be.

Amount of seed per acre.

1 acre of ground requires 9.7 lbs. of seed containing 72 % pure and germinating = 7 lbs. of pure and germinating seed. Using seed at 5 pence per pound, the cost for laying down an acre is about 4 shillings.

Mixtures.

Except for forming lawns and occasional pastures Fiorin is never sown pure. In permanent mixtures it should be used, but for short leys only on damp soils. In clover grass it is out of place. It is not customary to add more than 10 % of Fiorin to any mixture.

Reproduction by stolons.

Fiorin can readily be reproduced by its stolons. For this purpose *Richardson* recommended that stolons, harrowed out from broken up Fiorin-grass, should be planted in rows 4—6 inches apart, or simply spread out on the field and slightly covered over. *Sprengel* advises the cutting of the stolons into pieces about 3 or 4 inches long; these are to be sown, slightly covered, and then trodden in by sheep. On moist soils or in wet seasons, the nodes soon strike root and send out new shoots. In this way, the ground is more rapidly covered with grass than when seed is used.

Allied species.

An ally of Fiorin, American bent (*Agrostis dispar*, Mich.) has been recommended for cultivation. This is larger than Fiorin; it succeeds on drier and lighter soils, and is, like Fiorin, perennial.

XII. Reed Canary grass.

Phalaris arundinacea, L.

Explanation of plate.

Fig. A. The vegetative organs, shewing the stolons bearing scale-leaves, extravaginal buds, and roots.
,, B. A panicle in flower.
,, 1. The spikelet before flowering, side-view, shewing the outer glumes.
,, 2. The same in flower, shewing the three anthers and the two stigmas of the single flower.
,, 3. Spikelet before flowering, with the outer glumes removed, side-view; the inner glumes, the pales, and the young anthers are seen.

Fig. 4. The same from the ventral surface, shewing the upper inner glume, and the upper pale.
,, 5. The inner glumes detached, side-view; the lower is short, the upper, long.
,, 6. An inner glume, from the outer surface, shewing the short cartilaginous base, and the long membrane fringed with hairs.
,, 7. False fruit (seed), side-view; observe the inner glumes adhering to the pales.
,, 8. The same from the ventral surface, shewing the lower pale overlapping the upper.
,, 9. False fruit, dorsal surface.
,, 10. Caryopsis, side-view.
,, 11. Caryopsis from the dorsal edge, shewing the embryo at its base.
,, 12. Caryopsis from the ventral edge, shewing the hilum at its base.
,, 13. Transverse section near the apex of a leafy shoot, shewing the split leaf-sheath, and the convolute blade.
,, 14. Transverse section of the flat leaf-blade extending from the midrib to the margin, shewing the ribs and veins; the dark parts are »hard bast«.
,, 15. The ligule.

Botanical description.

Botanical description. This is, like Fiorin, a completely stoloniferous grass. The *stolons* (fig. A) are at first underground; ultimately they bend up, and reaching the light and air, develope green foliage and culms. The branches are all extravaginal; beneath the ground, their course is at first horizontal, sometimes they descend obliquely or vertically, but ultimately each bends up and forms a leafy branch or a culm in the air. On the underground stolons, roots and also colourless or brown scale leaves are produced; in the axils of the scales new branches often originate (See the buds in fig. A). At the base of the aerial parts, scales of a deep red colour are producd; these are succeeded higher up by green leaves with the blades short and rudimentary; then come the fully developed leaves with long blades. The *culm* is a firm reed, 3—7 feet high, quite smooth and shining. The *leaf-sheath* is smooth and split, the margins thin out into membranes which overlap; on the culm, the sheath is shorter than the internode (about half as long), and the nodes are accordingly left bare. The *leaf-blade* is convolute in bud (fig. 13), afterwards flat, firm, and about 1 inch broad; the margins are rough; the midrib is prominent on the lower surface (fig. 14); right and left, other ribs (about 6 or 7) stand out also on the lower surface; between these, still others are represented by fine striæ (fig. 14). On the transverse section, the veins (fibro-vascular bundles) are seen to extend from the upper to the lower surface of the blade (fig. 14). The *ligule* is long and somewhat acute (fig. 15). The *inflorescence* is a long panicle, spreading during flowering, but contracted both before and afterwards (fig. B). The *spikelet* is one-flowered (fig. 2), and has four glumes. The *outer glumes* (figs. 1 and 2) are pale green or somewhat purplish, almost equal, three-ribbed, and acutely keeled; the keel and the whole surface is made somewhat roughish by short bristle-like hairs. The *inner glumes* are shorter than the outer glumes, unequal, very narrow and fringed with hairs (fig. 3). Each is composed of a small basal piece which is ovate, cartilaginous, shining and glabrous; the remainder is a narrow, acute membrane fringed with hairs; the upper inner glume (to the right, fig. 5) is longer than the other.

The *lower pale* (fig. 3) is five-ribbed, cartilaginous, white, shining, obtusely keeled, and sparsely hairy. The *upper pale* (figs. 3 and 4) has not the usual structure, but resembles a lower pale: instead of being bicarinate is has a single obtuse keel; the other ribs are very indistinct. The *flower* (fig. 2) is composed of two *lodicules* which are ovate, acute, and half as long as the ovary; three *stamens*, with purple anthers; and a *pistil* formed of a long glabrous ovary terminated by a pair of feathery *stigmas*.

On *flowering* (fig. 2), the glumes and pales open at the apex; from this opening the stamens and stigmas protrude. The whole spikelet except the outer glumes forms the *false fruit* (figs. 7, 8, 9); it is composed of the caryopsis enveloped by the pales, to the keels of which the inner glumes now adhere; the lower pale almost completely covers the other parts (fig. 8), and like the inner glumes, has now assumed a brown colour. The *caryopsis* (figs. 10—12) lies free within the pales; it is laterally compressed, dark brown, and finely dotted; at the base of one of its edges, the small embryo is seen: at the base of the other, the hilum. The *false fruit* is 3.5 mm. long, the *caryopsis*, 1.5 mm.

Varieties.

Varieties. A variety of this grass having strips of white in its leaves (var. *picta.* Hort.), is often cultivated in gardens for ornament. *Sinclair* mentions similar leaves, as occurring in varieties of Cocksfoot and Fiorin.

Name.

The name of this genus is derived from the Greek and has reference to the shining seed (fig. 7). Being an ally of the grass which yields Canary seed, it is called Canary-grass. The variety having the leaves striped with white is known as »ribbon-grass« or »gardener's garters«.

History.

Sinclair cultivated this grass and recommended it for tenacious clays. On the continent, it was first cultivated by *Ruden* and *Palm*, about 1850. They recommended it more especially for soils where Red clover was uncertain.

Agricultural value.

Reed canary grass has, under certain conditions, great agricultural value. It is very suitable for wet soils: — the produce is very large, the culms 6—7 ft. high, and the aftermath good; further it is perennial, and its culms are never laid. As fodder, its value is low; after flowering it becomes hard and can only be used as litter. However, even for bedding purposes, its cultivation is very advantageous, since it grows readily, and on wet ground gives a larger yield than any other straw-producing grass. In mountainous districts, especially on wet lands and wherever there is scarcity of straw, great attention should be given to it.

Geographical distribution.

Occurrence, Climate, Soil, Manure. Reed canary grass is indigenous — to all *Europe* extending as far north as Lapland (68° N. lat); to *N. America;* to *Asia,* throughout Siberia and Japan.

Habitat.

It is common on the banks of sluggish rivers and shady ponds, in marshy places, and on flooded land.

Limits of altitude.

In Alpine regions it does not extend to high altitudes, but confines itself rather to the valleys. Its highest station on the Alps is Alt St. Johann (2,850 ft.). In Armenia, *Ledebour* mentions its occurrence at a height of 5,200 feet.

Climate.

This grass is very robust, withstanding almost all kinds of climate and season. It is little affected either by drought or cold, and thrives well in the shade.

Soil.

It succeeds best on stiff, wet land and on wet, flooded fields; prolonged flooding is not at all injurious. But even on sands of a decidedly dry type, it is also successful, though on such the produce is of course less abundant. It does not grow on peat.

Substances removed from the soil.

1000 lbs. of hay remove from the soil: —

Nitrogen . .	6.7 lbs.	Lime . . .	2.7 lbs.
Phosphoric acid .	7.1 ,,	Magnesia . .	0.9 ,,
Potash . . .	18.9 ,,	Silica . . .	30.6 ,,
Soda . . .	0.3 ,,	Sulphuric acid .	3.4 ,,

Manure.

For this grass, moisture is the great requirement; manuring is of but little importance. This is owing to the nature of the roots, which come out in great numbers from the stolons, spread over a large area of ground and penetrate deeply. Irrigation is very advantageous.

Growth.

Growth, Yield, Nutritive value. Reed canary-grass forms underground stolons which penetrate the ground in all directions; the ends of these come above ground, and form a moderately compact system of tall, solitary, reed-like culms. Although the leaves are few, they are very broad and 7—12 inches long.

Development.

Development begins early in spring, and growth continues till late in autumn. The produce is small in the year of sowing, but a full yield is obtained in the second year. Flowering commences about the middle of June. Cutting should take place before flowering, because the culms soon after become very woody, and the nutritive value is diminished.

Yield.

If the conditions are favorable, three cuttings may be obtained in a year. From a moist, sandy, humous soil, *De Gasparin* obtained per acre 12,140 lbs. of hay containing 1,516 % of nitrogen. From a black, sandy loam, with a clayey subsoil, *Sinclair* obtained 12,251 lbs. of hay, and from a strong tenacious clay, 17,016 lbs., per acre.

Nutritive value.

If cut young, the hay is readily eaten by cattle. The amount of albumin is very small as shown by the following analysis. 100 lbs. of hay, cut before flowering, contain 78.8 % of organic matter, composed of: —

Nitrogenous matter (N × 6.25)	4.2 %
Fibre	29.8 %
Non-nitrogenous extractives	43.6 %
Fat	1.2 %

(Albuminoid nitrogen 0.38 %, non-albuminoid nitrogen 0.301 %)

According to *Ritthausen* and *Scheven*, the nutritive matter is composed of 5.3 % nitrogenous matter, 37.4 % fibre, 35.0 non-nitrogenous extractives and 1.1 % fat. According to *Arendt*, the dry leaves contain 2.27 % nitrogen; the culms only 0.58 %. It is thus much more nutritive than straw. Its chemical composition closely approaches that of Maize fodder: — the amount of albumin is slightly less, and the fat is only one-half as much as in Maize. When young the presence of sugar gives the grass a sweet taste. It has often been advantageously used as fodder for horses. When the culms have become hard, they should be cut into chaff. For pasture, this plant is quite unsuitable, as the grass wants compactness, and the stubble is hard.

Harvesting the seed.

Harvesting, Impurities and Adulteration of seed. On dry ground, the seed is ripe about the beginning of July; on wet ground, rarely before August. When ripe, the panicle assumes a yellow colour, the sheaths of the upper leaves lose their green colour, and the seed can readily be rubbed out by hand. The panicles are then cut off, and the seed threshed out.

Yield of Seed.

According to *Hannemann*, about 180 lbs. of seed are obtained from an acre.

Impurities and Adulterations.

Commercial seed is usually tolerably pure. Adulterations are rarely attempted and are easily detected.

Seed quality.

Amount to be sown per acre.

Seed and Amounts to be sown. Good seed should have 95 % purity and 60 % germination. 1 lb. of pure seed contains on an average 660,000 grains; the weight per bushel varies from 44 to 48 lbs. One acre of ground requires 21 lbs. of seed containing 57 % pure and germinating = nearly 12 lbs. of pure and germinating seed. The average price is 1s. 4d. per lb.

Reproduction from cuttings.

This grass can be reproduced, not only from seed, but also from cuttings of the stolons (rhizome). The cuttings are laid down at intervals of one foot, and slightly covered. They soon strike root, begin to grow, and cover the ground in all directions. Reproduction from seed is simpler, and more certain.

Sowing.

Mixtures.

Perhaps the best plan is to grow it by itself, or if the soil is wet, it might be mixed with a little Fiorin. For forming irrigated grass-lands it is mixed at times with other species of grass and clover. It ought not to be used in alternate husbandry, because its underground stolons are very difficult to eradicate.

Other Uses.

Its mode of growth makes it suitable for binding loose banks near running water; also by its growth soft, marshy ground may be rendered firm and compact. The dense shade which it casts on the ground beneath it, makes it also useful for destroying Horse-tails, Coltsfoot, and other weeds which cannot grow in shade.

XIII. Smooth-stalked Meadow-grass.

Poa pratensis, L.

Explanation of plate.

Fig. A. Entire grass in flower, shewing two stolons, a tuft of branches, and a panicle.
,, 1. The spikelet before flowering, shewing the two glumes and four lower pales.
,, 2. The same, shewing three pales detached and suspended by the web of woolly hairs (Distinction from *Poa annua).*
,, 3. A lower pale seen from the side, shewing the hair along the marginal rib, along the keel, and at the base.
,, 4. The spikelet in flower, seen from the side.
,, 5. The upper pale and the flower with the stamens removed.
,, 6. A group of false fruits (seeds), shewing the interlacing webs.
,, 7. The false fruit (seed) lying on its side. (Note. In figs. 7—12 the hairs have been removed).
,, 8. The same from the ventral surface, shewing the stalk and inner pale.
,, 9. Apical false fruit lying on its side; the stalk is half the length of the whole fruit, and is terminated by a globular rudiment.
,, 10. False fruit (seed): — observe the truncate stalk, the upper pale without a groove and its keels overlapped by the lower pale.
,, 11. False fruit, on its side, shewing the lower pale. (By a mistake on the part of the lithographer the ribs are too prominent.)
,, 12. False fruit with the outer pale removed, lying on its side; shewing the ciliated keels of the upper pale.
,, 13. Caryopsis, dorsal surface.
,, 14. Caryopsis, ventral surface.
,, 15. Caryopsis, on its side.
,, 16. Transverse section of the caryopsis: — the ventral surface (above) is slightly concave, and the back rounded.
,, 17. *a—d.* Transverse sections of a leaf-sheath at different heights.
  a. at the base; no fold.
  b. three-fourths above the base; the fold at a maximum.
  c. near the apex; the fold slight.
  d. an older sheath; the fold obliterated by stretching.
,, 18. Transverse section of a leaf-blade, shewing the veins and »bulliform cells«.
,, 19. The short, obtuse ligule of a culm leaf.

Botanical description.

Botanical description. Smooth-stalked meadow-grass forms tufts of branches loosely connected together by long underground stolons. There are thus two kinds of branches (fig. A): — 1. the long, underground, horizontal stolons: extravaginal, 2. the aerial tufted branches: intravaginal.

To form the *stolon,* the bud must first pierce the sheath which encloses it and thus become extravaginal. Growth is continued in a horizontal direction for a long distance underground. As the stolon lengthens it produces roots and colourless scale-leaves. The terminal scale-leaf forms a rigid cone covering the growing point and thus serves as a protecting and piercing organ. Ultimately the end bends up and becomes a leafy branch in the air (fig. A) which ultimately developes a culm. The course of the stolon is not always horizontal; at times, especially when it comes from the centre of a large tuft, it descends vertically into the ground, but later on the end bends up as before to reach the light and air (fig. A).

Those branches which form the tufts are produced from a number of intravaginal buds lying close together; these grow vertically upwards, directly into the air, and become leafy branches which later on produce culms and flowers (fig. A).

The *culm* is smooth (hence the term »smooth-stalked«), erect, 1—3 ft. high, cylindrical or somewhat compressed and two-edged. The young *leaf-sheaths* are smooth, glabrous, laterally compressed, entire, and deeply folded opposite the midrib (fig. 17b) except at the base (fig. 17a). *Hackel* describes a similar fold in *Festuca amethystina* and *Festuca scaberrima*. Folding begins about one-fourth above the base, reaches a maximum three-fourths up (fig. 17b), then decreases, and at the summit is again very slight (fig. 17c). By the growth of the parts contained within the sheath, the fold is soon obliterated and ultimately ruptured. Old sheaths and those on the culms are split in this way. *Döll, Ascherson*, and others describe the sheath as split: this is only true of the old sheaths; young sheaths are always entire. The *leaf-blade* is folded in the bud: its other characters depend upon the variety (see below). Each blade contains seven strong and well-developed fibrovascular bundles (veins) extending from the upper to the lower epidermis, and a variable number of weaker bundles between these (fig. 18). The epidermis of the upper surface has six bands of specialised cells forming three symmetrical pairs of »Bulliform cells« *(Duval Jauve)* or »Gelenkzellen« *(Tschirch)*, shewn in fig. 18. The furrows corresponding to the stronger veins are very slight and the blade is accordingly almost ribless (fig. 18). The *ligule* is short and obtuse (fig. 19). The *inflorescence* is a pyramidal panicle, closed before, but spreading during and after flowering (fig. A); the colour is bluish green, frequently variegated with brownish purple. Each *spikelet* contains 3, 4 (fig. 1) or 5 flowers. The *glumes* (fig. 1) are almost equal, acute, and ciliated towards the apex of the keel (fig. 4). The *lower pales* have long, silky, curly hairs which interlace with one another and with those of adjoining pales forming the *Web* (*»Lana conjunctiva«*); these hairs are longest at the base, but they also extend three-fourths up the keel and the marginal ribs; on the latter they are shortest (fig. 3). The presence of the web is easily recognised when the spikelet is broken; the detached pales do not fall to the ground but remain suspended by it (fig. 2). By this character, *Poa pratensis* and *trivialis* are readily distinguished from *Poa annua:* — in the latter, the hairs are present but do not form a web; accordingly, the pales when detached fall to the ground. The *upper pale* is very slightly shorter than the lower, and has a pair of ciliated keels only seen where the lower pale has been removed, as in fig. 12. The *flower* (fig. 5) is composed of two lodicules, broad at the base, deeply bifid and eroded at the summit; three stamens; and a pistil formed of an ovary longer than the lodicules, bearing two feathery stigmas (fig. 5).

Flowering goes on as in Perennial rye-grass. When ripe, the spikelet breaks up into *false fruits* (seeds); each is composed of a caryopsis contained in a pair of pales, and a stalk lying in front of the upper pale (fig. 10). The webs bind the false fruits together; those from one spikelet interlacing with those from another to form clumps (fig. 6). If a ripe panicle of *Poa pratensis* is touched by a passing animal the webs attach the seeds to its body; the meaning of the hairs is thus plain: — they facilitate the distribution of the seed by passing animals. The *caryopsis* lies free within the pales which are accordingly easily detached. The *lower pale* becomes broad towards the apex, and the ribs are not prominent on the surface (fig. 11); the margins overlap and conceal the keels of the upper pale (fig. 10). The *upper pale* is very slightly concave and has no groove (fig. 10). The *stalk* of that false fruit which occupied the apex of the spikelet is half as long as the fruit itself, and is terminated by a small globular head formed of barren pales (fig. 9); the other false fruits have a truncate stalk (fig. 10). The *caryopsis*, like the upper pale, is very slightly concave on the ventral surface; the back is rounded (fig. 16); at the base, on the ventral surface is the rounded hilum (fig. 14), on the dorsal, the embryo (fig. 13); both ends are pointed, and the apex is crowned by the withered styles (not by a tuft of hairs).

Length of false fruit	2—3 mm.
,, ,, caryopsis	1—1.6 ,,
,, ,, stalk	$^1/_9$—$^1/_2$ of false fruit
Thickness of stalk	0.08 mm.

Varieties.

Varieties. Several varieties occur. The following are of agricultural importance: — 1. Common smooth-stalked meadow-grass. *(Poa pratensis* var. *vulgaris,* Döll) with a bright green colour and the radical leaves long and slightly concave; 2. Broad-leaved meadow-grass *(Poa pratensis* var. *latifolia,* Koch); this is the »Blue grass« of America; it has a bluish green colour, and the radical leaves are short and broad; 3. Narrow-leaved meadow-grass *(Poa pratensis* var. *angustifolia,* Smith.) with its radical leaves long, narrow, permanently folded and bristle-like.

Name.

The name »Smooth-stalked« is applied to this grass to distinguish it from *Poa trivialis* which is »Rough-stalked«. It is sometimes called »Common meadow-grass«, and in N. America, »*Blue-grass*«.

History.

As this grass was often confounded with *Poa trivialis* many erroneous ideas have arisen, and many contradictory statements been made regarding it. About the middle of last century, the Narrow-leaved variety was cultivated in England and N. America under the name of »*Bird-grass*«. Only recently, however, has smooth-stalked meadow-grass come into general cultivation.

Agricultural value.

Because of its fine and early foliage, this grass is very suitable either for spring pastures or as »bottom grass« in hay. *Block* regards it as one of the best pasture grasses; if its aftermath were larger, it would certainly be the best »bottom-grass«. It is perennial, and forms a fine, complete sward. Crested dogstail, although its seed is dearer, has the advantage in the aftermath, and is accordingly preferable on the better kinds of soil.

Geographical distribution.

Occurrence, Climate, Soil, Manure. This grass is indigenous — to the whole of *Europe,* extending to Lapland, Nova Zembla, and Spitzbergen; to *Asia,* in the whole of Siberia extending to 75° 36′ N. lat., in Kamtschatka, and the Caucasus; to the whole of *N. America,* extending to Greenland, and the straits of Magellan. It also occurs in *Australia.*

Habitat.

Smooth-stalked meadow-grass is common in meadows, on walls, in hedges, etc.

Limits of altitude.

It is very abundant on the Lower Alps ascending to 6,600 ft., at Albula 6,900 ft., at Julier near Stalla 6,300 ft., at Bevers 5,600 ft., at Schuders and Mesocco 6,000 ft., at Zermatt 5,000—5,750 ft., at Churwalden 4,150 ft. and at Engelberg 3,000 ft.

Climate.

Since smooth-stalked meadow-grass produces abundant roots spread over a wide area of ground, and kept out of reach of the sun by the underground stolons, it can bear extreme drought without injury. That is the chief reason why it is so widely distributed in the western parts of N. America. In the same way, extreme cold does not affect it; the cold cannot obtain access to the deep roots.

Soil.

It thrives very well upon any loose, good, warm soil which is rich in humus. On the rich prairies of N. America, for example, it forms the bulk of the grass; often, even the whole vegetation. When abundant, it is regarded as a sign of good soil, and »Blue-grass farms« usually fetch the highest prices. It is not so successful on soils which are heavy and compact as on those which are light or moderately heavy. It can be grown on a dry sand containing sufficient organic matter and manure. It also thrives on moist soils provided they are not too stiff; and even on moorland which is well-drained; excessive wetness or sourness prevents its growth. Poverty in humus, especially when combined with extremes of lightness or heaviness, produces the same result.

Substances removed from the soil.

According to the Zurich analyses, 1000 lbs. of hay remove from the soil: —

Nitrogen	9.9 lbs.	Magnesia	0.4 lbs.
Phosphoric acid . .	8.2 ,,	Lime	1.9 ,,
Potash	15.0 ,,	Sulphuric acid . .	1.3 ,,
Soda	0.5 ,,	Silica	24.3 ,,

According to older analyses 1000 lbs. of hay contain: —

	Way and Ogston. lbs.	Knop and Arendt. lbs.	Collier. lbs.	Ritthausen and Scheven. lbs.
Nitrogen . . .	—	16.6	15.8	14.6
Potash	20.0	—	18.8	—
Soda	0.4	—	—	—
Lime	2.9	4.3	2.1	—
Magnesia . . .	1.4	2.0	1.4	—
Phosphoric acid .	5.2	3.9	4.4	—
Sulphuric acid .	2.2	—	2.1	—
Silica	17.2	27.0	13.5	—

Appropriate manuring is beneficial; fresh manure is much less useful than that which is thoroughly decomposed. Manure.

Growth, Yield, Nutritive value. As already explained Smooth-stalked meadow-grass produces very long underground stolons which ultimately bend upwards and form tufts of branches in the air. Growth.

In the second year, the stolons become very numerous; accordingly, the ground becomes thickly and completely covered with grass. In the first year, the amount of herbage is small and no culms are produced; here and there, bare spots of ground occur. Full development is reached in the second and third year of growth. The shoots come up tolerably early. The time of flowering varies with the situation, and extends from the end of May to the middle of June. In the second cutting, the produce consists entirely of long leaves (4—12 inches, accordingly to the quality of the soil); no culms are produced, not even such as lie upon the ground and strike root (as some authors erroneously state); these leaves grow very slowly, the aftermath is therefore small. *Vianne* obtained from a loose, light, fertile soil, per acre: —

1st cutting (in flower) . .	4,650 lbs. hay.
2nd „	1,600 „ „

Sinclair obtained, per acre, from a clay loam, rich with the vegetable matter of active peat: —

1st cutting (in flower) . .	2,871 lbs. hay.
2nd „	1,425 „ „

This grass is best cut when in flower. When older, the culms are dry and hard, and the leaves, though still green, tough and leathery. 100 lbs. of grass give, on an average, 35 lbs. of hay. Harvest.

According to *Sprengel*, the yield per acre may be assumed to be 3,500—4,400 lbs. of hay; *Vianne* obtained 6,250 lbs.; *Sinclair* 4,296 lbs. According to the Zurich analyses 100 lbs. of hay contain 79.8 % of organic matter, composed of: — Yield. Nutritive value.

Nitrogenous matter ($N \times 6.25$)	6.2 %
(albuminoid nitrogen 0.75 %, non-albuminoid nitrogen 0.28 %)	
Fibre	41.9 %
Non-nitrogenous extractives	30.3 %
Fat	1.4 %

According to older analyses, the composition of the hay is: —

	Way.	Scheven and Ritthausen.	Collier. I.	Collier. II.
Nitrogenous matter . . .	8.9 %	9.1 %	10.0 %	6.4 %
Fibre	32.7 %	35.4 %	24.0 %	19.4 %
Non-nitrogenous extractives	37.0 %	34.9 %	45.0 %	51.3 %
Fat	2.3 %	2.5 %	2.5 %	4.2 %

The nutritive value is thus seen to be somewhat less than that of hay of medium quality.

Harvesting the seed.

Harvesting, Impurities and Adulteration of seed. Commercial seed comes, for the most part, from N. America. A small quantity is obtained in Europe from wild plants; its growth for seed will scarcely pay. When a seed-crop is grown it should be cut before all the seeds are ripe, to prevent loss. Mowing should begin when the panicles are turning brown, and the spikelets are becoming clustered together. Those seeds which are not yet ripe mature during drying. After threshing, the seed should not be packed immediately, but spread out in thin layers on the ground; if packed, the temperature rises and this causes the germinating power to diminish. As already explained, the long woolly hairs cause the seeds to become massed together in small clumps; this renders sowing very difficult. Before sowing, in order to allow the seed to be properly distributed over the ground, the hairs should be removed. This is done either by rubbing with the hand or with suitable rubbing and threshing machines followed by the winnowers; the cleaned seeds are then sifted off. If, as is usual, all the hairs are not removed at first, the operation is repeated. In this way seed of good appearance and free from woolly hairs is obtained and this fetches the highest price in the market.

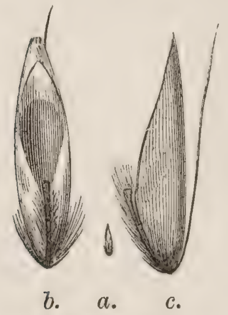

Fig. 33.
Tufted hair-grass, *Aira cæspitosa*, L.
a. False fruit (seed) natural size;
b. ventral surface;
c. side-view × 8.

Yield.

The yield of seed is about 220—440 lbs. per acre.

Impurities.

In commerce, seed from which the woolly hairs have not been removed is frequently met with. In this condition, it forms clumpy masses; by the inexperienced, the woolly hairs are taken for fungi and the seed is looked upon as mouldy. Although apparently low-priced, such seed should not be purchased; its real value is much less than that of cleaned seed, as the hair and chaff removed in cleaning amounts to 20—40 % of the whole.

Adulterations.

Uncleaned seed is frequently adulterated with this valueless hair and chaff, and if such seed be bought, one pays money for a deal of utterly worthless material. Tufted hair-grass (fig. 33) is often used as an adulterant; it is readily detected. Silky bent grass (fig. 34) is rarely used; it is less objectionable than the former because it is only an annual.

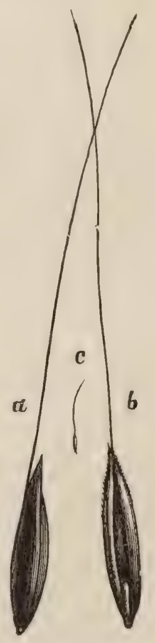

Fig. 34.
Silky bent grass, *Apera spica-venti*, P. B.
False fruit (seed) with the awn.
a. side-view.
b. ventral surface × 7.
c. natural size.

Seed quality.

Seed and Amount to be sown. The average purity, determined from numerous analyses, is 84.1 %: the germinating power in the light, taking the average of 101 analyses, is 48 %. Good and well-cleaned seed should have 95 % purity, and 50 % germination = 47.5 % of pure and germinating seed.

Amount of seed per acre.

1 lb. of pure seed contains, on an average, 2,400,000 grains. 1 acre of ground requires, on an average, 17½ lbs. of seed containing 48 % pure and germinating = 8.4 lbs. of pure and germinating seed.

Mixtures.

Unless for ornamental purposes, *Poa pratensis* is never sown alone. In mixtures for temporary and permanent leys, especially on dry soils, it is used to form »bottom grass«. It is not suitable for clover-mixtures. After sowing, the seed should never be covered, but only rolled, because it germinates better in light than in darkness.

Distinguishing characters.

Poa pratensis closely resembles *Poa trivialis* and is often confounded with it. It is distinguished by the following characters: — the stolons are underground; the colour is darker; the ligule is short and obtuse; and the culm is smooth (see table, pp. 82, 83).

XIV. Rough-stalked Meadow-grass.

Poa trivialis, L.

Explanation of plate.

Fig. A. Entire plant shewing the mode of growth and the panicle.
,, 1. A three-flowered spikelet before flowering.
,, 2. A two-flowered spikelet broken, shewing a pair of pales suspended by the web of woolly hair.
,, 3. A pair of pales detached, side-view, shewing the web of hair attached only to the base of the outer pale.
,, 4. Spikelet in flower. The reproductive organs of both flowers are visible.
,, 5. The lodicules, pistil, and basal portion of the upper pale.
,, 6. A group of false fruits (seeds) shewing the entangled webs. The pales to the left are rudimentary and must therefore have occupied the apex of a spikelet.
,, 7. False fruit (seed), the »web« removed, ventral surface. The margins of the lower and the two keels of the upper pale are seen. The middle line of the inner pale is pressed down into the deep groove of the caryopsis.
,, 8. False fruit, side-view. The lower pale is acute and the ribs are prominent on its surface.
,, 9. False fruit from which the outer pale has been removed, seen partly from the side and partly from the ventral surface.
,, 10. Caryopsis, dorsal surface, shewing the embryo.
,, 11. Caryopsis, side-view.
,, 12. Caryopsis, ventral surface; shewing the hilum and the deep groove.
,, 13. Transverse section of the caryopsis grooved above (ventral) and rounded on the back (dorsal).
,, 14. Transverse section through the uppermost sheath of a leafy branch, showing two entire leaf-sheaths surrounding a folded leaf-blade.
,, 15. Transverse section of a leaf-blade.
,, 16—18. The long, acute ligule of a culm leaf.
,, 19. The short ligule of a radical leaf.

Botanical description.

Botanical description. The branches of this grass are all extravaginal and bear green leaves; they vary however in the extent of their horizontal curve. Some ascend directly into the air to form a loose tuft (fig. A to the left). Others take at first a horizontal direction along, never beneath, the surface of the ground; ultimately these bend up and ascend into the air. From the nodes lying on the ground roots and secondary branches are again produced. These like their predecessors either ascend directly or creep at first along the ground. In smooth-stalked meadow-grass the horizontal branches are *underground* whereas here they are *on* the ground, and this constitutes the only essential difference in the modes of growth of these grasses.

The base of the *culm* lies on the ground; at the second or third node it ascends and reaches a height of 2 or 3 feet. It is always rough beneath the panicle: this roughness is most readily perceived when the culm is drawn across the tongue. *(Döll* found in Baden a single variety with the culms and the sheaths quite smooth).

The *leaf-sheaths* (fig. 14) are rough from below upwards, laterally compressed, two-edged, and entire at least in youth. Later, they may be more or less ruptured and split in consequence of the growth of the parts which they surrounded. On the culms, they are always split in this way. The young sheath is never folded like that of *Poa pratensis* (fig. 14).

In the bud, the *leaf-blade* is folded. On each side of the midrib there are usually five well-marked veins. Other veins between these are indistinct and vary in number. Right and left of the midrib on the upper surface there is deep groove lined with »bulliform cells« (fig. 15). On both surfaces above the stronger veins, the ribs are slightly marked, each rib is occupied by a »bast bundle« separate and quite distinct from the fibro-vascular bundle (fig. 15) which forms the vein beneath.

The *ligule* of the culm-leaves is long, *acute*, and eroded (figs. 16—18). On the radical leaves it is much shorter (fig. 19).

The *inflorescence* is an erect, ovate panicle, contracted before, but spreading during flowering; its colour is pale green, rarely variegated with violet.

The flat *spikelet* usually contains three flowers (fig. 1). The *lower glume* is one-ribbed, the *upper*, three-ribbed and longer: both have rough teeth along the keel (fig. 1). The *lower pale* is five-ribbed; the long woolly hairs forming the web are confined to its base; along the keel and marginal ribs the hair is quite short and inconspicuous (fig. 3). The *upper pale* is rough on the two keels which have minute teeth. When the spikelet is broken the pales remain suspended by the web of hairs (fig. 2); the same is the case with smooth-stalked meadow-grass.

On *flowering* (fig. 4), the pales open, and the stamens and stigmas project at the sides; the anthers discharge their pollen quite early before the filaments have bent down; self-fertilization is thus possible.

When ripe, the spikelets break up into *false fruits* or »seeds« in the same way as those of smooth-stalked meadow-grass. The webs of hair interlace and bind the fruits together into clumps (fig. 6). Both pales envelop the caryopsis very closely; the upper can be removed only with great difficulty. The *lower pale*, seen from the side, tapers slightly becoming somewhat acute towards the apex; and the ribs are prominent (fig. 8); the margins overlap the ventral surface very slightly so that the keels of the upper pale are quite uncovered (fig. 9). The *upper pale* has a deep longitudinal groove as it is pressed down into a corresponding groove in the caryopsis (fig. 9). The stalk of that false fruit which occupied the apex of a spikelet is half as long as the fruit itself; its conical termination is merely the rudimentary pale (fig. 6 to the left); the other false fruits have the stalks short and truncate (figs. 7 and 8). The ventral surface of the *caryopsis* has a deep groove (figs. 12 and 13), and the back is obtusely keeled (fig. 13); hilum is suborbicular and lies at the base of the groove (fig. 12.); both apex and base are *rounded* (fig. 10 and 12).

Length of false fruit (seed) 2—2$^1/_2$ mm.
,, ,, caryopsis . . . 1—1$^1/_2$ mm.
,, ,, stalk . . . . $^1/_7$—$^1/_2$ of the false fruit
Thickness of stalk . . . 0. 08 mm.

Varieties. **Varieties.** There are no varieties of agricultural importance.

Name.

In Switzerland the peasants call this species »Natural grass« (Natur-Gras) because of its readiness to spring up and take possession of uncultivated land; in such cases it forms the bulk of the grass. The term rough-stalked refers to the roughness of the culm beneath the panicle.

History.

It was cultivated in England some centuries ago. In 1681 Worlidge recommended it. He called it »Orchiston grass« because of its abundance in the celebrated grasslands of Orchiston, near Salisbury in Wiltshire. About the year 1785 *Boys* cultivated it in the county of Kent. At the present time it is in high esteem and in common cultivation, both in Britain and on the continent; in mountainous districts it always forms the staple of the natural grass.

Agricultural value.

In Lombardy, it is known as the »Queen of forage plants«, although its value scarcely justifies this designation. It is so highly prized there because in the first cutting the yield is large and the fodder excellent. This is the case on the irrigated grass-lands, and more especially on the mountains and the moist districts near rivers. The produce of aftermath is, however, very scant consisting merely of diminutive grass a few inches in height. In this condition the peasants do not recognise it and look upon it as a worthless plant. If the produce of aftermath were as abundant as that of the first growth, rough-stalked meadow-grass would occupy the first rank among fodder-grasses; but such is not the case. At the first mowing its height is 2 to 3 ft., at times 4 to 8 ft.; while in the aftermath it is quite diminutive. Since it has a strong perennial character, its principal use is to form »bottom grass« in permanent pastures.

Geographical distribution.

Occurrence, climate, soil, manure. Rough-stalked meadow-grass is indigenous — to all *Europe*, extending to Ireland and Lapland, where, according to Wahlenberg, it often forms the bulk of the herbage; to *Asia*, in Caucasus, Georgia, and throughout Siberia and Japan; to *Africa*, in Algiers and the Canary Islands. It has been introduced into *America*.

Habitat.

It occurs wild in good meadows and pastures, by the sides of ditches, among cereals, on bare spots in clover and lucerne fields, etc. In Northern and Central Europe it is a natural denizen of all good grass-land.

Limits of altitude.

Its highest altitudes have not yet been recorded; it has, however, been found at 8,000 ft. On the Bavarian Alps, it ascends to 4,500 ft., at Fex, to 6,400 ft., in the Rhinewald, to 4,600—5,250 ft., at Schwefelberg, to 4,600 ft., and at Churwalden, to 4,250 ft.

Climate.

It succeeds best where the climate and soil are moist, *e. g.* on mountains, and by the side of running water.

Drought is hostile to it; accordingly it cannot thrive in situations much exposed to sun. Excessive drought causes the plant to turn red and the branches which creep along the ground either dry up and disappear or become short, hard and wiry. On the return of moisture growth again begins and the creeping branches reach their normal length. It is not readily affected by cold; sometimes however injury is done; the plant rapidly recovers on the return of warmth.

Soil.

Rich, moist soils which are stiff rather than light are preferred by this grass. It thus thrives on all good clays and loams. On light, dry soils its place should be taken by smooth-stalked meadow-grass.

Substances removed from the soil.

1000 lbs. of hay remove from the soil, according to the Zurich analyses: —

Nitrogen . .	9.8 lbs.	Magnesia . .	1.2 lbs.
Phosphoric acid	12.7 „	Lime . . .	7.2 „
Silica . . .	26.3 „	Silica . . .	19.3 „
Soda . . .	1.1 „	Sulphuric acid	4.2 „

According to *Way* and *Ogston*, 1,000 lbs. of hay (excluding water) contain: —

Phosphoric acid .	7.6 lbs.	Silica	31.2 lbs.
Potash	24.5 ,,	Sulphuric acid . .	3.7 ,,
Magnesia	2.7 ,,	Potassium chloride	5.7 lbs.
Lime	0.73 ,,		

According to *Way* 1000 lbs. of hay contain 13.4 lbs. of Nitrogen, according to *Ritthausen* and *Scheven* 14.4 lbs.

This grass is thus seen to be rich in Potash and Phosphoric acid; accordingly it removes from the soil a large amount of these substances. As the roots are not deep, the superficial layer is readily impoverished. To secure a good crop the superficial layers require to be rich in nutriment.

Manure.

Growth is much favoured by an application of compost in autumn. The superficial layer is thereby rendered soft and nutritive, root-growth is favoured, and the whole plant becomes quite luxuriant. Horse-litter roughly spread in autumn is indirectly favourable; where the litter is thickly spread, a number of other grasses perish, and rough-stalked meadow-grass takes their place. On the other hand, when the soil is copiously supplied with liquid manure especially during summer, growth is arrested; it begins again in autumn and spring when moisture returns. The Rothamsted experiments show that Nitrate of Soda combined with mineral manures favours, while ammonia compounds retard the growth of this grass.

Irrigation.

Irrigation is very suitable. On the Orchiston meadows, inundated during part of the winter, the culms reach a height of 7 or 8 ft. (of course only in the first cutting). During summer the water must have a good outflow.

Growth.

Growth, Yield, Nutritive value. At first, during the year of sowing, rough-stalked meadow-grass produces a tuft of ascending branches and culms which strike root only at the base. Later in the year, branches are produced, which spread out horizontally along the ground, giving off roots as they go. These produce branches on their own account, and in this way, even during the first year, the ground becomes completely occupied. Next year, culms are produced in such abundance that light cannot find an entrance, Under these conditions the basal parts become etiolated, and have a tendency to rot away. Under favourable circumstances the grass is so compact that the scythe can scarcely cut through it. After the first cutting, tufts of very short leaves, and creeping branches which strike root are produced, but no erect culms of leafy branches to make a good aftermath. When sown on bare spots in fields, or on bare fallow, the produce, first of all, consists of erect branches and culms; later, creeping branches extend from the periphery of the tuft in all directions, and strike their roots into the ground. The creeping branches from adjoining tufts interlace with one another, and thus the ground comes to be completely occupied by grass. In the following spring a new crop of erect branches is produced. Soils of good quality may in this way be rapidly covered by grass. When a bare fallow is left to itself, it is often taken possession of and soon overrun by rough-stalked meadow-grass, the seeds of which occur in the ground. During the first year, the ground may remain partially bare, but, in the second, it will certainly be covered if the conditions are at all favourable.

Development.

As mentioned above, the yield is small during the first year, but, in the second, the plant is at its best. In the spring, it shoots somewhat early, although the culms are produced somewhat later than those of smooth-stalked meadow-grass, apparently because it grows in localities where the soil is moist and as a consequence the rise in temperature more gradual. It flowers from the end of May till the end of July, about the time of hay-cutting.

Harvest.

When it forms a main constituent of a hay crop, it should if possible be cut before flowering, because the culms are very compact and readily become rotten at the base, especially on moist land. In the first cutting it reaches a height of 1 to 3 ft. and if the conditions are very favourable 4 to 5 feet. According to *Sinclair* 100 lbs. of grass give 32.6 lbs. of hay; according to *Vianne* 34 lbs.

Yield.

Sinclair obtained an annual yield of 3,522 lbs. of hay per acre, *Vianne* 5,280 lbs. and *Pinkert,* in the second year, 3,170 lbs.

Nutritive value.

100 lbs. of hay contain, according to the Zurich analyses, 77.0 % of organic matter, composed of:

Nitrogenous matter (N × 6.25)	6.1 %
Fibre	29.9 %
Non-nitrogenous extractives	38.8 %
Fat	2.2 %

(albuminoid nitrogen 0.77 %, non-albuminoid nitrogen 0.21 %)

According to older analyses the nutritive matter contained in the hay is: —

	Ritthausen and Scheven.	Way.
Nitrogenous matter	9.0 %	8.4 %
Fibre	34.5 %	33.0 %
Non-nitrogenous extractives	33.1 %	34.3 %
Fat	3.2 %	3.2 %

The amount of albumin is thus less than in hay of average quality, but the proportion of fat is slightly higher.

Harvesting the seed.

Harvesting, impurities and adulterations of seed. Except in one district of Denmark, rough-stalked meadow-grass is not cultivated on a large scale for seed: it is usually gathered from wild plants. The seed is ripe about the end of July. It may be stripped from the plants by hand; it is, however, better to cut off the tops and thresh out the seed after ripening.

Cleaning is difficult because the woolly hairs are so abundant and so »webby«. It is best to rub the seed by hand over a sieve; by repeating this operation, all the woolly hairs can be removed. Anyone can collect seed for himself from bare places in wheat or lucerne fields, on which *Poa trivialis* often grows in abundance. This is the more necessary to obtain genuine seed, which is very rare in commerce.

Yield of seed.

Pinkert reckons 396 lbs. of seed per acre a fair yield, when the plant is grown by itself.

Impurities and Adulterations.

In commerce the seed of *Smooth-stalked meadow-grass* is very often substituted for that of Rough-stalked meadow-grass. The seed of *Poa pratensis* (fig. 3, 7—11, Plate 13) is brownish, slightly stouter, more convex on the back, and has more woolly hair on the base and especially on the *back;* the furrow on the ventral surface is very slight. The seed of *Poa trivialis* (fig. 6 and 8, Plate 14) has a bluish tinge, is somewhat narrower, has less woolly hair at the base, none at all on the back, and the ventral surface is deeply furrowed. Adulteration with *Annual meadow-grass* (*Poa annua,* fig. 35) is not so common; this seed has few hairs at the base and is almost twice as large; the pales are slightly winged at the margin, and the ribs at the back are very distinct. Now and then, the seed of *Wood meadow-grass (Poa nemoralis)* is mixed with that of *Poa trivialis*; the former seed is slightly shorter, more acute and more slender; the colour is less pronounced and the hair at the base has almost disappeared. *Poa sudetica,* Hænke (fig. 36), is a frequent impurity; its seeds are larger. *Molinia cœrulea,* Mœnch (fig. 38), and *Glyceria distans,* Wahlenberg (fig. 37), with short seeds rounded off at the ends frequently occur.

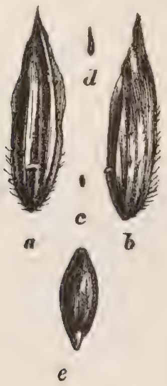

Fig. 35.
Poa annua, L.
a. and *b.* False fruit (seed) × 7;
e. caryopsis × 7;
d. false fruit;
c. caryopsis, natural size.
(after Nobbe.)

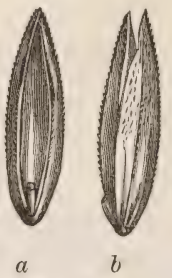

Fig. 36.
Poa sudetica,
Hænke
False fruit × 8.
a. ventral surface;
b. side-view.

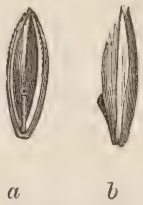

Fig 37.
Glyceria distans,
Wahlenberg.
False fruit × 8.
a. ventral surface;
b. side-view.

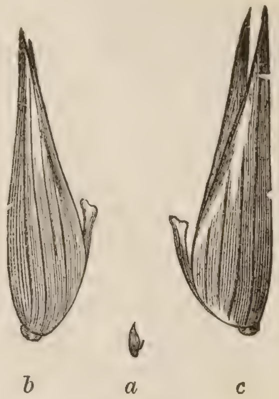

Fig. 38.
Molinia cœrulea,
Mœnch.
False fruit, side view.
a. natural size;
b. and *c.* × 8.

Seed quality.

Seed and amounts to be sown. Seed of good quality should have 90 % purity and 50 % germination = 45 % of pure and germinating seed. 1 lb. contains from 2½ to 4 million seeds. The weight per bushel varies from 11 to 17 lbs. An acre of ground requires 19½ lbs. of seed containing 45 % pure and germinating = 8¾ lbs. of perfectly pure and germinating seed.

Mixtures.

In hay mixtures it is used only on irrigated land which is cut once a year. When several crops are to be taken, or when the land cannot be irrigated, it should not be used. In permanent pasture mixtures it is most suitable for rich soils and sheltered situations.

Comparative table shewing the characters by which Poa pratensis and Poa trivialis are distinguished.

Organs.	**Poa pratensis.**	**Poa trivialis.**
Leafy branches.	Two kinds: 1. extra-vaginal with scale leaves forming stolons underground. 2. intra-vaginal with foliage leaves forming tufts.	All the branches extravaginal; some extending horizontally *above* ground, never underground.
Culms.	Erect, smooth.	Ascending, rough.
Leaf-sheaths.	Smooth, entire*) on the leafy branches, and with a longitudinal fold opposite the midrib.	Rough, entire on the leafy branches, no fold.

*) Contrary to the statements of *Döll, Lund* etc.

Organs.	**Poa pratensis.**	**Poa trivialis.**
Leaf-blade.	Rough, with 7 veins, the bast bundles extending from epidermis to epidermis and fused with the vascular bundles.	Rough, usually with 5 veins, the bast bundles distinct from the vascular bundles.
Ligule.	Short, truncate.	Long (short only on the leafy shoots.) acute.
Spikelets.	Three- to five-flowered.	Usually three-flowered.
Lower pale.	Long woolly hairs *(lana conjunctiva)* on the base and back.	The web of woolly hairs confined to the base.
False fruit. (seed)	The lower pale, seen from the side, is broad towards the apex, and its ribs scarcely project on the surface. The upper pale is slightly concave; its keels are covered by the margins of the lower pale.	The lower pale, seen from the side, is pointed towards the apex, and the ribs stand out on the surface. The upper pale has a deep longitudinal groove; the keels are bare and not overlapped by the margins of the lower pale.
Stalk.	0.08 mm. thick. The stalk of the apical false fruit of each spikelet bears at its apex a *globular* appendage formed of rudimentary pales.	0.04 mm. thick. The stalk of the apical false fruit of each spikelet bears at its apex a *long and acute* appendage formed of rudimentary pales.
Caryopsis.	Acute at the apex and base; slightly *concave* on the ventral surface.	Rounded at the apex and base; provided with a *deep* groove on the ventral surface.

XV. Alsike clover.

Trifolium hybridum.

Explanation of plate.

Fig. A. Portion of the plant, in flower.
,, 1. Flower, side-view.
,, 2. Calyx.
,, 3. Flower with the calyx and standard removed, side-view.
,, 4. The same, with the wings removed.
,, 5. Flower with the calyx and corolla removed, shewing the essential organs.
,, 6. Pistil.
,, 7. Fruit with the persistent style and calyx.
,, 8. Broad side of the seed.
,, 9. Edge of the seed, shewing the hilum.

Botanical description.

The primary *stem* of Alsike clover is ascending, tubular, glabrous, 1 to 3 ft. high, and usually branched; all the heads of flowers spring from the axils of the leaves, none being terminal. The *leaflets* are glabrous, elliptical-ovate, toothed on the margin, and obtuse at the apex. The *stipules* are green and taper off to a fine point. The stalks or *peduncles*, which bear the capitula, are longer than the leaves. The *capitula* are spherical, without an involucre, and composed of very many flowers. The *pedicels* of the flowers are two or three times as long as the tube of the calyx; they become reflex after flowering. The *calyx* is glabrous, its tube short and ten-ribbed, about one-third or one-fourth as long as the corolla; its teeth are five, linear-lanceolate, and almost equal in length. The *corolla* is at first white, later rose-coloured: the young flower-heads are therefore white, but when older, they also become rose-coloured. The petals are free. The base of the *standard (vexillum)* forms a split tube which surrounds the bases of the wings and keel; its apical portion, the limb, is erect and flatly spread out during flowering, but before and after that stage, it is folded along the middle line. The two *wings (alæ)* are inserted on the calyx-tube; their claws are long and narrow; the limb is broad, and has a prolongation directed backwards (fig. 3). The two lowest petals form the *keel (carina)*; the long and narrow claws are free from one another posteriorly, but cohere anteriorly (fig. 4). The wings adhere to the keel at a point situated in front of the appendages of the wings. The *Stamens* are ten in number; the nine lower form a split tube; the upper free stamen covers the slit. The open passage to the honey lies right and left of the base of the free stamen. The *pistil* is composed of a long ovary containing 2 to 3 ovules (figs. 3 to 6), and a style bearing a terminal stigma projecting somewhat beyond the anthers (fig. 5).

The structure of the flower is essentially the same as that of white clover. Hence, although no observations have been made upon the fertilisation of Alsike, it may be inferred that the fertilising process is much the same as that of white clover (which see).

When the flower is ripe, both calyx and corolla persist; at this stage, the corolla is brown and membranous, and the standard folded longitudinally. The *fruit* is a flat, 1 to 3 seeded pod, longer than the calyx; the pericarp is thin, and the bent style persists at its apex. The *seeds* are small and slightly flattened; the radicle is seen projecting on one of the margins, occupying about two-thirds of the edge (fig. 8). The form of the seed when viewed from the flat surface (leaving the radicle out of account) is that of an ellipse acute at both ends. Along one edge, the radicle forms a projecting band with an obtuse apex. The circular spot lying immediately beneath the apex of the radicle is the hilum (fig. 9). The colour of the seed, which varies with the ripeness, may be either yellowish-green, or dark olive-green, often speckled.

Varieties. No varieties are known.

Name. *Linnæus* gave this clover the specific name *hybridum* because he regarded it as a cross between the red and the white species. It is often called Swedish clover, and Alsike, because of its extensive cultivation in the Swedish village called Alsike, near Upsala.

History. *Linnæus* recommended it for cultivation, but its history prior to this is uncertain.

Whistling states that it was in cultivation in Northern France about the end of last century. In 1834, *George Stephens* brought it to England from Sweden, where it had been cultivated long before. In Northern Germany, it was known about the beginning of the present century. Between 1840 and 1845, it came into general use, especially in Saxony. It found its way slowly into the Southern districts. Only within the last 10 years, has its cultivation in Switzerland become general. Now, however, it is much esteemed there because of its excellent properties.

Agricultural value. Alsike is of a more perennial character than red clover, and can, on an average, be used for three years, and, at times, for five. Admixed with other plants, it may last even longer. It is little affected by extreme seasons. From soils on which other clovers will not grow, an abundant harvest of first class fodder may be obtained.

Geographical distribution. **Occurrence, climate, soil, manure.** This species is indigenous to *Europe,* in Central France (rare), Germany, Switzerland, Northern Italy, Austria Hungary, Croatia, Servia, Bosnia, Poland, Thracia, Central and Southern Russia, Scandinavia (except the North of Norway), and Lapland; to *Africa,* in Algiers; to *Asia,* in the Caucasus and Siberia. It does not occur in *N. America.*

Habitat. In the wild state, Alsike is met with in damp meadows and pastures, on the grassy banks by riversides, and on damp uncultivated land.

Limits of altitude.

It occurs at high altitudes on the Alps. It is found at Gurnigel, as an escape from cultivation, at a height of 3900 ft. In Grisons, Dr. Brügger met with it at 3800 ft. On the Bavarian Alps, it ascends to 2500 ft., and on the Caucasus, to 3300 ft.

Climate.

Alsike is little affected by climatic influences, as it has, for a long time, been acclimatised and widely cultivated in Northern Europe. To cold, it is almost insensitive. In winter, it is not liable to be uprooted, and late frosts seldom lead to its destruction. A moist season is rather favourable than otherwise. On bleak mountains, Alsike has therefore great value, and the results are everywhere very favourable. It does not resist persistent drought very well, because its root-system is relatively superficial. Though not destroyed by drought, the produce is much reduced.

Soil.

Alsike thrives best on damp or moist loams and clays. It can be cultivated on stiff clays with an impermeable subsoil, even on those which are too wet for other clovers. On moorlands, if they are not excessively wet, and on ochreous soils rich in iron, it may also be cultivated. According to the account of *Lippe-Weissenfeld,* it succeeds very well on light fertile soils containing marl. Soils of a light and dry type are least suited for it, although, in Northern Germany, it is often sown, and used as a pasture plant in such cases. Then, of course, the produce is somewhat meagre. In Saxony, according to *Pinkert*, it has been cultivated on the poorest granitic soils.

Substances removed from the soil.

1000 lbs. of Alsike clover remove from the soil:

Nitrogen . . .	24·6	lbs.	Magnesia . . .	5·1	lbs.
Phosphoric Acid .	4·1	„	Lime	13·8	„
Potash	11·3	„	Silica	1·7	„
Soda	1·2	„	Sulphuric Acid .	1·7	„

Manure.

As Alsike has a superficial root-system, the corresponding layer of soil must be rich in fertilising matter. That is the reason why manure should be applied after harvesting the preparatory crop. Well-manured and well-tilled clover-sick land is suitable for it. It can be more frequently repeated than red clover, since, as yet, there is no such thing as clover sickness for Alsike.

Irrigation.

This is the only species of clover which is suited for irrigation.

Growth.

Growth, yield, nutritive value. At the base, the stem is bent and lies along the ground, without rooting; the rest of the stem is ascending. From this mode of growth, it is clear that Alsike, grown by itself, may readily be laid, and then it is liable to rot away at the base. To this it is especially subject on damp soils where the plants are very close together. Usually it is a more leafy plant than red clover.

Development.

When sown in a cereal crop, some of the plants usually flower in autumn. In spring, it is later than red clover, and only comes into flower between the first and second cuttings of the latter, and for long after this it remains green. If Alsike is in flower when its first crop is taken, the second cross does not reach full maturity.

Harvesting.

The nutritive value is at its highest when the plant is in flower, and that, accordingly, is the best time for cutting. It can either be used green or made into hay. As it contains a larger proportion of water than red clover, drying is more difficult. The leaves contain much more available nutritive matter than the stems, and, therefore, special care must be taken to prevent, as much as possible, loss of leaf during hay-making. When in flower, about 25 % of the whole plant is leaf, and, at that time, according to *Ritthausen,* the leaves contain 8·9 % of albuminoid matter, whereas the stem has only 1·95 %. Assuming an acre to yield 21,100 lbs. of Alsike, *Ritthausen* reckons the total amount of albuminoids at 728 lbs.; 383 lbs. in the leaves, and 345 lbs. in the stems. If the leaves are allowed to fall off, more than half of the total albuminoid matter is lost. Further, the albuminoids contained in the leaves are of more value than those in the stems, because a larger percentage can be assimilated, and thus the actual loss is much greater than half the total albuminoid matter.

Yield.

As remarked above, the first crop is much larger than the second; the latter, on an average, is about half as large as the former. In Saxony, *Pinkert* estimates the yield at 4000 to 4840 lbs. per acre and sometimes it becomes as high as 5720 lbs. *Schober* estimates the produce of the first crop at 3080 lbs. per acre; and, according to Werner, the total yield of the two cuttings ranges from 3500 to 4400 lbs. per acre. The plants in the first crop are tall, often 5 feet high.

Pasture.

Alsike is very suitable for pastures, as new shoots are rapidly produced after depasturing by cattle. For this reason, Alsike often forms an important constituent in pasture mixtures, more especially in Northern lands. It is not so readily eaten by stock as white clover, probably because of its slightly bitter taste.

Nutritive value.

Chemical analysis shows that the nutritive value is very high, and in this respect this is not inferior to white clover. According to *Wolff*, the composition is as follows: —

	Water	Organic matter	Albumin	Fibre	Non-nitrogenous extractive	Fat
Green Alsike	%	%	%	%	%	%
At the commencement of flowering	85·0	13·5	3·3	4·5	5·1	0·6
Amount digested			2·1	5·8		0·4
(Ratio of albuminoid to non-albuminoid matter 1 : 3·2)						
In full flower	80·0	16·2	3·3	6·0	6·3	0.6
Amount digested			1·8	6·9		0·3
(Ratio of albuminoid to non-albuminoid matter 1 : 4·3)						
Dry Alsike	14·0	79·8	15·4	27·6	33·4	3·4
Amount digested			8·6	35.6		1·9
(Ratio of albuminoid to non-albuminoid matter 1 : 4·6)						

Seed harvest.

Harvesting, impurities, and adulteration of seed. Alsike yields a very profitable seed crop. In Sweden, and in Northern and Southern Germany, large quantities are grown for this purpose. Moist soils are not very suitable for a seed crop; for this purpose, those soils should be selected which are of a drier type. On these, the clover neither becomes too tall, nor is it liable to be laid. The seed must be taken from the first crop, because the second does not usually reach maturity. The latter can only be used for seed when the first cutting has taken place very early in the season, about the middle or the end of May. In this case, the crop will be ready about the beginning of September. The seed readily falls off the plant, and may be largely diminished from this cause if certain precautions are not taken to prevent the loss. The crop ought to be taken when the heads have become brown, and when the seeds are of cheesy consistence. The produce must be very carefully dried. The best mode of procedure is to separate the flowers at once; drying may then be proceeded with. Threshing is not at all difficult. It is important, however, before threshing, to allow the seeds to become thoroughly dry;

this prevents them from being crushed during threshing. In commercial seed, broad crushed grains often occur to the extent of 10 per cent or more; their presence indicates that the seed has not been properly dried before threshing.

Yield of seed.

Each pod contains from one to three seeds; as these are very small, the yield is not so great as is the case with red clover. *Werner* estimates the yield at 132 to 264 lbs. per acre, and *Schober*, at 396 lbs. In Saxony, it usually varies from 264 to 300 lbs. per acre.

Impurities.

The impurities of Alsike are much the same as those of red clover; dodder is specially frequent. Among 48 samples examined at the Swiss control station, during the season 1881—1882, one half contained dodder. One lb. of seed contained, on an average, 6,200 dodder seeds; in one case, as many as 85,700. The size of the dodder seed approaches closely to that of Alsike; it is, therefore, very difficult to separate them. When cleaned with a $^3/_4$ m.m. sieve, the smaller dodder seeds are eliminated, but the larger still remain. Sorrel *(Rumex acetosella)*, Ribgrass *(Plantago lanceolata)*, Self-heal *(Prunella vulgaris)*, Cornchamomile *(Anthemis arvensis)*, Stitchwort *(Stellaria media)*, Chickweed *(Cerastium triviale)*, Bladder campion *(Silene inflata)* etc. are very frequent impurities. When such occur to the extent of 5 per cent, or more, which is often the case, the seed should not be used. Ribgrass, for example, is often specially hurtful. The seed of white clover *(Trifolium repens)* and Trefoil *(Medicago lupulina)* are frequently present in Alsike seed.

Adulterations.

Old and discoloured seed is often dyed green to give it a fresh appearance. This fraud is easily detected by rubbing the seeds with a white cloth which readily removes the artificial green colouring matter. The artificially added colour lies on the surface of the skin, whereas the natural colouring matter is seated *in* the seed skin. Hence it is that very little colour can be removed from fresh Alsike seed when it is rubbed with a cloth, whereas artificial colouring matter shews itself on the cloth at once. Formerly, Alsike was adulterated with green coloured stones, but attempts in this direction have now ceased.

Seed quality.

Seed and amounts to be sown. The average purity of 100 samples analysed at the Swiss control station was found to be 95 %, and the germination 72 %. Good commercial seed should have 97 % purity and 75 % germinating power = 73 % of pure und germinating seed. Care should, of course, be taken that no dodder is present. One lb. of pure seed contains, on an average, 707,000 seeds. One pound of 73 % seed, therefore, contains 526,000 pure and germinating seeds. A bushel varies in weight from 94 to 100 lbs. 12·3 lbs. of seed, containing 73 % pure and germinating, are required per acre = 9 lbs. of pure and germinating seed.

Mixtures.

A pure sowing of Alsike is not advisable because a larger yield and better quality of fodder is obtained from a mixture. It may be sown along with red clover, but grasses should be added to the mixture, e. g. 50 % Red clover, 25 % Alsike, 25 % Timothy. Timothy and Alsike are two fodder plants extremely suitable for heavy, moist soils, and they give the heaviest hay. Cocksfoot and perennial rye-grass also form suitable mixtures with Alsike; Italian and false oat-grass are not so suitable. As pointed out in the case of white-clover, so here, the mixture is not at all deteriorated by the presence of grasses. The grasses, in fact, serve as supports, and tend to prevent Alsike from being laid.

Trifolium elegans.

A species of clover closely allied to Alsike is *Trifolium elegans*, Savi. It is distinguished from Alsike by the following characters. The stem is solid and downy near the apex, and the margins of the leaves are doubly toothed. The plant is slightly smaller than Alsike; and the flower-head is redder, rounder, and more elegant in appearance (hence the specific name). In other respects there is a close resemblance between the two. The seeds are identical in form, colour, and size. *W. Löbe* states that *Trifolium elegans* growing along with Alsike is frequently a cause of disease in animals in South-Brabant. *Werner* is of opinion that the diseases observed, in cases where the animals have been fed on Alsike, are due to the presence of *Trifolium elegans* in it. He says: »In 1871, horses were fed on Alsike clover produced in Eastern Prussia. After 10 days, the mucous membrane of the mouth became swollen and excoriated. When the fodder was changed, these symptoms very soon disappeared. Horses having white feet, or white spots on the skin or head, were seen to have these spots swollen, and covered with large scars produced by the exudation of an albumin-like discharge. This rendered the animals incapable of work for a long period. The disease failed to appear among horses not marked with white. No experiments have been made on cattle.«

XVI. Sheep's fescue.

Festuca ovina, Hackel.

The figures relate exclusively to the genuine variety of sheep's fescue.

Explanation of plate.

Fig. A. Entire plant; shewing the setaceous leaves, a young, contracted panicle (to the left), and a panicle in flower and spreading (to the right).
„ 1. Spikelet before flowering.
„ 2. Spikelet in fruit.
„ 3. False fruit, ventral surface.
„ 4. False fruit, side-view.
„ 5. False fruit, dorsal surface.
„ 6. Caryopsis, ventral surface.
„ 7. Caryopsis, dorsal surface.
„ 8. Caryopsis, side-view.
„ 9. Transverse section of a young leafy shoot; the leaf-sheath is split, and the blade folded.
„ 10. Transverse section of the blade of a fully developed leaf (after Hackel).
„ 11. The two-eared ligule. —

Distinguishing characters.

Sheep's fescue *(Festuca ovina,* Hackel) is distinguished from the other species by the following characters. The growth is compact and tufted (fig. A). All the branches are intravaginal. The leaves are permanently folded and bristle-like with 3 to 7 ribs, the ligule two-eared, and the leaf-sheath split. The ovary is glabrous. The following varieties of the species are distinguishable: —

1. Genuine Sheep's Fescue, *F. ov.* L. var. *vulgaris* Koch
2. Hard Fescue, *F. ov.* L. var. *duriuscula,* Koch
3. Fine-leaved Fescue, *F. ov.* L.. var. *tenuifolia,* Sibthorp
} *Fest. ovina* L. *Fest. ov.* subspecies *eu-ovina,* Hackel
4. Sheep's Fescue of Valais, *F. sulcata,* Hackel var. *valesiaca,* Schleicher
5. Striated Sheep's Fescue, *F. sulc.* var. *genuina,* Hackel
} *Fest. sulcata,* Hackel *F. ov.* subspecies *sulcata,* Hackel Mon.
6. Chamois Fescue, *F. rupicaprina,* Hackel (*Fest. ov.* subspecies *frigida,* var. *rupic.,* Hackel Mon.)
7. Sheep's Fescue of Haller, Fest. Halleri, Hackel *(Fest. ov.* subspecies *lævis* var. Halleri, Hackel Mon.)
8. Alpine Sheep's Fescue, *Fest. alpina,* Suter. *(Fest. ov.* subspecies *alpina* Hackel Mon.)

The first two subspecies, viz. the genuine and the hard sheep's fescue have most importance in agriculture. The botanical description and the plate relate exclusively to genuine sheep's fescue and to the sub-variety of it designated *genuina* by *Hackel.* The rest of the text applies equally to genuine and hard fescue. The latter is more robust in its growth, and this constitutes the chief agricultural difference between it and genuine fescue. For brevity, both varieties are spoken of as sheep's fescue.

Botanical description.

Botanical description of genuine sheep's fescue. Genuine sheep's fescue forms a compact tuft of grass. All the branches are intra-vaginal, and enclosed in parent sheaths which are persistent and do not split up into fibres (fig. A). It produces numerous *culms,* which are very slender, and 8 to 24 inches high; each has two nodes, and is somewhat angular and rough beneath the panicle. The *leaf-sheaths* on the culms are also somewhat rough, and split except at the very base (fig. 9). The *blade* (fig. 10) is light-green and folded in the bud; this fold persists and gives the bristle-like or setaceous character to the leaf. A layer of cells with very thick hard walls *(sclerenchyma)* lies immediately beneath the epidermis in the form of a ring represented dark in fig. 10. This complete skeleton beneath the epidermis, causes the leaf to retain its cylindrical form when the rest of the cells are dried and shrivelled up. (If the sclerenchyma ring is incomplete, as in striated sheep's fescue, then the dry blade between the bundles of sclerenchyma will fall in, and appear furrowed). The *inflorescence* is a one-sided panicle, spreading when in flower, 1 to 4 inches in length, with axis and branches rough: the lowest branch is one half or one third as long as the whole panicle. The *spikelet* (fig. 1) is three- or four-flowered; its form is elliptical or somewhat linear; the colour is green, often with a violet tint, but when the plant is grown in the shade, its colour may be lighter. The *glumes* are narrow and lanceolate; the lower (figs. 1, 2), one-ribbed, the upper (figs. 1 and 2), three-ribbed; both have fine short hairs on the keel. The *lower pale* (figs. 1 and 2) is five-ribbed, awned, and usually rough beneath the apex. The *upper pale* has two ciliated keels. The *flower* is composed of two ovate, bi-dentate lodicules as long as the ovary, three stamens, and a pistil with an ob-ovate, glabrous ovary, and a pair of terminal styles.

Flowering goes on as in perennial rye-grass. When ripe, the spikelet becomes spreading (fig. 2) and then breaks up into false fruits in the ordinary way, so that a portion of the axis of the spikelet forms the stalk in front of the upper pale (fig. 3). The *false fruit* composed of the two pales and, the enclosed caryopsis (figs. 3 to 5), is 3 to 4 mm. long without the awn, and 4 to $5^1/_2$ mm. including the awn. The *stalk,* about one fourth the length of the pale (excluding the awn), is obliquely truncate and slightly concave at its apex. It is covered with stiff bristles sloping upwards (figs. 3 and 4). The *caryopsis* (figs. 6 to 8) is about 2 mm. long, compressed, and dark brown in colour; the ventral surface is slightly concave (fig. 6), and has a hilum almost as long as the caryopsis itself; the dorsal surface is slightly convex (fig. 7).

Sub-species and varieties.

Varieties. The sub-species are distinguished by the following characters.

1. Genuine Sheep's fescue has just been described in detail.

2. Hard fescue has stouter culms, larger spikelets, and thicker leaves. *Festuca duriuscula,* the hard fescue of commerce, is a vigorous variety of genuine sheep's fescue (*Hackel* has determined it as *F. ov. eu-ovina vulgaris firmula*).

3. Fine-leaved fescue (var. *capillata, Lam. paludosa, Gaud., tenuifolia, Sibth.)* is always designated in commerce as *Festuca ovina, tenuifolia.* Low stature, fine hair-like leaves, and awnless spikelets, at once distinguish it. It has no special value as an agricultural plant, and should be used only for ornamental purposes, more especially in shady places.

4. Sheep's fescue of Valais. The ring of sclerenchyma beneath the epidermis of the leaf is incomplete, whereas in the three preceding varieties it is complete; when dry, therefore, the leaf becomes furrowed. The whole plant is covered by a fine layer of wax which gives the grass its characteristic bluish-green and glaucous appearance. The wax can readily be rubbed off by the fingers. It is widely spread over southern Europe.

5. Striated Sheep's fescue resembles the preceding, but is not glaucous. It has the same geographical distribution as the preceding form.

6. Chamois fescue is distinguished from all the preceding varieties by having the whole lower half of its leaf-sheath entire. The five-ribbed leaf and the glaucous spikelets with short awns distinguish it from the following variety. It is met with on the chalk-formation of the northern Alps.

7. Sheep's fescue of Haller has the leaf-sheath like the preceding, but the blade is seven-ribbed; the spikelets have long awns and are not glaucous. It is very abundant on the Southern Alps.

8. Alpine sheep's fescue is distinguished from all the other varieties by its short anthers which are only 1 mm. long (in the other varieties, 2 to 3 mm.). It grows on the high Alps (Engadine, Gemmi, Rawil, Bagnes, Bex, Château d'Oex, Faulhorn etc.).

History.

In olden times, sheep's fescue was cultivated in N. Germany. *Mauke* in 1818 recommended it. He says »This is the most valuable of all pasture grasses for sheep; their rational rearing depends largely on a knowledge of it. Sheep prefer it to all other grasses, and they thrive best where it is abundant. Experience shows that in localities where other grasses grow along with sheep's fescue, he sheep leave the others untouched, and seek out the fescue, on which they become fat, and produce fine wool. To improve our sheep, all dry and barren spots should, therefore, be sown with this grass, and such land can be turned to no better account.« *Mauke's* praise requires considerable limitation; it shows that, at the beginning of the century, agriculturists appreciated the value of this fescue.

Agricultural value.

Though this grass is insignificant in size, it is, nevertheless, of great importance, because it thrives on poor and dry sands where better grasses cannot grow. Further, it tends to improve the soil, as it produces roots in abundance. On good land, it should not be sown, or, at most, only a very small proportion should be used, because more valuable plants can be produced. When the soil is so dry and poor that no other fodder plants can grow upon it, then sheep's fescue should be used. It serves only as pasture; upon poor ground it does not grow sufficiently high for mowing. Cattle do not like it, but sheep eat it more readily; however, when other grasses can be obtained, the sheep rather avoid it. It is rough and hard even in its youth, and cattle only to eat it when forced by hunger. Therefore, it ought only to be grown as a pasture plant on poor soils. On good soils it becomes somewhat larger, and can then be used as bottom grass in hay mixtures.

Geographical distribution.

Occurrence, climate, soil, manure. Genuine sheep's fescue is indigenous to *Europe*, extending to Iceland and Spitzbergen; to Sub-Arctic and Eastern *Asia*, to Japan and the Himalayas; also to *British North America*. It has been introduced into other parts of *North America*.

Hard fescue is common throughout Western and Southern *Europe*, but rare in Central, and very rare in Northern and Eastern Europe. It occurs neither in Greece nor Sicily. In *Asia*, it occurs on Caucasus, Armenia, Altaï and Mongolia. It is also found in New Holland und New Zealand As different varieties are spoken of as *F. duriuscula*, these localities must be taken with reserve *(Hackel)*.

Habitat.

Sheep's fescue abounds on dry pastures and sandy land, on the borders of fields and roadsides, on sandhills, mountains, and other dry localities. It extends from the sea level to the high Alps, and is always most abundant on dry ground.

Limits of altitude.

On the Alps, genuine sheep's fescue reaches altitudes of 5,900 ft. (Matt 2,800 ft., Rofflen on the Splügen road 3,440—3,930 ft., St. Moritz 5,900 ft.). Hard sheep's fescue rises to 6,890 ft. (summit of Mount Camoghe 3,940—4,920 ft,, Bevers and Celerina 5,740 ft., St. Moritz 5,900 ft., Pass of Foscagna 6,890 ft.; at Maloja the form *lævigata* occurs at 5,900—6,890 ft.). Fine-leaved fescue rises at Faido to 2,370 ft., in other localities it probably occurs at higher elevations.

Climate.

Temperature and climatic influences have little effect on this grass. It bears extreme drought as is clearly shewn by the fact that it is very common in Southern Europe at the period of greatest drought. Extreme drought, no doubt, checks its growth, but immediately moist weather returns, a fresh start is made.

Soil.

It thrives on all kinds of soil except such as are wet and sour. Its appropriate place in cultivation is on light dry soils, especially those which are poor, shallow, and silicious. In such cases, it is a great boon to the agriculturist.

Substances removed from the soil.

1000 lbs. of hay of genuine sheep's fescue remove from the soil: —

Nitrogen	11.7 lbs.	Magnesia	0.6 lbs.
Phosphoric Acid	4.6 „	Lime	2.5 „
Potash	16.8 „	Silica	37.3 „
Soda	0.2 „	Sulphuric Acid	1.7 „

According to *Hruschauer,* 1000 lbs. of hay of genuine sheep's fescue (the glaucous variety) removes from a calcareous soil: —

Phosphoric Acid	3.0 lbs.	Lime	6.5 lbs.
Potash	4.7 „	Silica	6.0 „
Soda	3.5 „	Sulphuric Acid	1.2 „
Magnesia	2.3 „		

Manure.

On sandy soils, sheep's fescue should be sown after a manured root crop. If the land can be irrigated other and better grasses should take its place.

Growth.

Growth, yield, nutritive value. Sheep's fescue forms a compact tuft of grass which produce numerous culms 8 to 24 inches high. The radical leaves are dry and hard, and the culm leaves few. The tufts are not deeply seated in the ground, and, as the grass gets older, they become more and more prominent, and the mowing is correspondingly difficult. The tufted mode of growth shows clearly that this grass by itself cannot form a complete cover for the ground, bare spaces must occur between the tufts.

Development.

During the year of sowing, the produce is very small. In the second and third years, the maximum yield is obtained. Afterwards, the produce diminishes. A pure sowing of sheep's fescue ought, therefore, to be ploughed up after a ley of four years. A mixture containing a large percentage of sheep's fescue should be treated in the same way. About the beginning of April, the green leaves appear, and by the end of May, or the beginning of June, the grass is in flower.

Depasturing.

Depasturing must commence very early, because the leaves soon harden, and then they are not eaten by sheep. In dry weather growth stops, but later in the year, when the weather is moist, growth begins again. In favorable seasons depasturing can go on until winter.

Yield.

Vianne obtained 4,180 lbs. of hay per acre from hard fescue, whereas *Bürger* obtained only 1,280 lbs. per acre from a crop of genuine sheep's fescue. On poor soil, the yield is thus very small. According to *Vianne,* 100 lbs. of grass give 38 lbs. of hay; according to *Block,* 35 to 40 lbs. These figures show that the proportion of water lost by drying is relatively small.

Nutritive value.

According to the Swiss analyses 100 lbs. of hay of *Festuca ovina genuina* contain 78·2 % of organic matter, composed of: —

Nitrogenous matter (N × 6·25) (albuminoid nitrogen 0·739 %, non-albuminoid nitrogen 0.438 %)	7.4 %
Fat	3.0 %
Fibre	31.6 %
Non-nitrogenous extractives	36,2 %

According to *Collier*, 100 lbs. of hay of *genuine sheep's fescue* contain 81·7 % of organic matter, composed of: —

Nitrogenous matter (N × 6·25)	5.6 %
Fat	3.7 %
Fibre and non-nitrogenous extractives	72.4 %

According to *Way*, 100 lbs. of hay of *hard fescue* contain 81.4 % of organic matter, composed of: —

Nitrogenous matter	10.4 %
Fat	2.9 %
Fibre	33.3 %
Non-nitrogenous extractives	34.8 %

In the first two analyses, the hay is poorer in albuminoids, in the last, richer, than meadow hay of medium quality. The proportion of fat and fibre is greater, while that of non-nitrogenous extractives is less than in meadow hay.

Seed harvest. **Harvesting, impurities and adulteration of seed.** Sheep's fescue produces abundance of seed, easy to harvest, and, is therefore, comparatively cheap. The seed is ripe about the end of June, or the beginning of July. If allowed to become over-ripe, it readily falls off and is thus lost. Mowing should commence when the spikelets readily break up, and when the grain has a leathery consistence. After drying, the seed is treated like that of perennial rye-grass, or the plants may be housed and dried. Threshing is very easy. A great deal of seed is obtained from wild plants, which abound on barren ground and on roadsides.

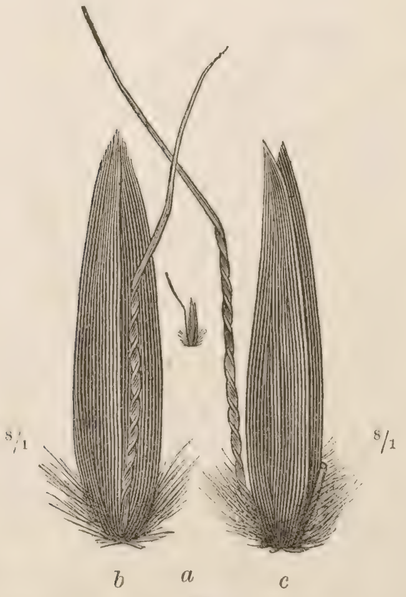

Fig. 39.
Wavy hair grass.
Aira flexuosa, L.
False fruit.
a. Natural size.
b. Dorsal surface × 8.
c. Side-view × 8.

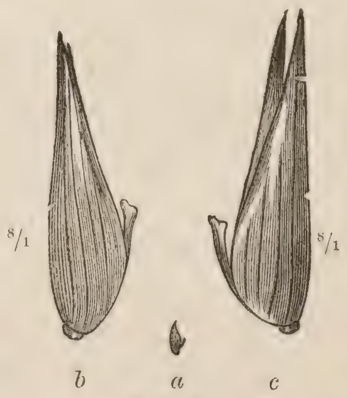

Fig. 40.
Molinia cœrulea,
Mœnch.
False fruit, side-view.
a. Natural size.
b. and *c.* × 8.

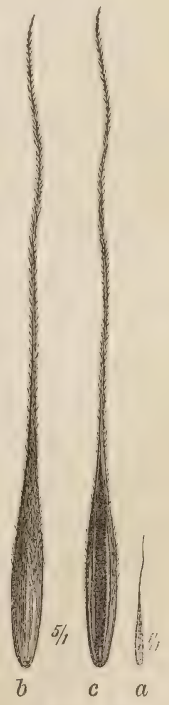

Fig. 41.
Vulpia bromoides,
Link.
a. False fruit, natural size.
b. Dorsal surface.
c. Ventral surface × 5.

Impurities and adulterations. *Aira flexuosa* (fig. 39) is a common impurity which is easily recognised. At times, *Molinia cœrulea* (fig. 40) is intentionally added; the absence of the awn, the swollen base, and the gaping pales clearly distinguish it. *Vulpia bromoides* (fig. 41) is rarely used as an adulterant; it is darker in colour, longer and narrower, and the pale has a very long awn.

Quantity to be sown.

Seed and Amounts to be sown. Good commercial seed should have a purity of 90 %, and a germination of at least 50 %. The germinating power is sometimes higher, but very frequently lower than this. One lb. of pure seed contains, on an average, 680,000 grains. The weight per bushel varies from 10 to 15 lbs., and is on an average, 12 or 13 lbs.

The average amount of seed required per acre is 28 lbs. containing 45 % pure and germinating = 12·6 lbs. of pure and germinating seed.

Mixtures.

Sheep's fescue should never be sown pure, even when the soil is quite poor. Other plants should be mixed with it, in order to obtain a complete sward. On extremely poor soils, kidney vetch *(Anthyllis vulneraria)* is appropriate; on somewhat better sandy soils, white clover, smooth-stalked meadow-grass, and perhaps Timothy should be used. It is most advantageous in a ley of four years' duration. In mixtures for temporary and permanent grass land, it may play the part of a bottom grass, but the percentage used should always be small.

Sowing.

When Sheep's fescue forms the bulk of a mixture, it is best to sow it in autumn, after potatoes, along with rye. After harvesting the rye, depasturing should not be commenced till the grass has obtained a firm footing, because the young plants are so easily uprooted by sheep. Rolling is advisable after carrying the rye, and also in the spring of the following year. Such treatment gives the plants a better hold on the ground, and presses into the soil those which have been uprooted by frost during winter. On sandy soils, sheep's fescue is a good preparation for rye; in such a case, a good rotation would be: — 1. Rye. 2. Potatoes, manured. 3. Rye. 4—7. Sheep pasture.

Allied species.

Amethyst blue fescue *(Festuca amethystina,* L.), is a near ally of sheep's fescue. It is distinguished from all other species of the genus by its leaf-sheath, the lower half of which is entire and has a *deep fold*. The hairy ovary is also very distinctive. The leaves are exceedingly long, fine, hair-like, and bluish-green, becoming furrowed when dry. The spikelets are awnless. It occurs in dry localities and on sunny spots in pine-woods. It is found in mountainous countries of Central Europe.

XVII. Sainfoin.

Onobrychis sativa, Lmk.

Explanation of plate.

Fig. A. Apical portion of a plant, shewing the leaves and inflorescence.
„ 1. The flower, side-view.
„ 2. The same, with the standard removed.
„ 3. The same, with the standard and calyx removed.
„ 4. The stamens.
„ 5. The pistil.
„ 6. The fruit, seen from the surface. The edge to the left is uppermost in the flower.
„ 7. The seed, from the surface.
„ 8. The same, from the edge.
„ 9. Transverse section of the fruit, shewing the pericarp and seed.

Botanical description.

The stem is erect or ascending, one to two feet high, ribbed, and downy. The *leaf* is imparipinnate, composed of six to twelve pairs of opposite leaflets and an odd terminal one. The leaflet is linear-oblong, or oblong-obovate in shape, and downy on the lower surface.

The *inflorescence* is a many-flowered, spike-like raceme, terminating a long axillary peduncle. The *calyx* (figs. 1 and 2) consists of a short tube with five teeth twice as long as the tube itself. The three lower teeth are directed downwards. The margin of the calyx tube, between the two upper teeth, is broad and obtuse. The *corolla* is bright rosy-red in colour, with darker veins. The petals are free from one another (polypetalous). The *standard* is large, and its limb only slightly erect. The *wings* are shorter than the calyx teeth, and completely covered by the standard. The *keel* (figs. 1, 2 and 3) is as long as the standard, the claws short, the limb large, and obliquely truncate at the apex. The *stamen-tube* has a pair of slits, one to the right and one to the left, at the base of the upper free stamen; by these, insects obtain access to the honey (figs. 3 and 4). The *ovary* is ovate and contains one ovule; the *style* is long and bent at a right angle near the middle; the *stigma* is terminal, capitate, and projects beyond the anthers (fig. 5).

Insect fertilisation goes on as in white clover. When the keel is depressed by the weight of the insect, the stigma and the stamens come into contact with the lower surface of the insect's body; fertilisation and transfer of pollen are thus accomplished. When the insect flies away the keel returns to its original position, and again encloses the sexual organs. There is no experimental evidence, to show whether the flowers remain sterile if insects do not visit them; such is very probably the case, as the stigma projects considerably beyond the anthers, and the distance becomes increased during the period of flowering. The honey is accessible to insects with short probosces and, accordingly, the number of guests is very great. *Müller* observed 29 different species, but the honey-bee is the most frequent visitor.

The *fruit* (figs. 6 and 9) is one-seeded, indehiscent, and compressed. The seed is attached to the upper margin which is thick and straight. The lower margin is curved, thin and comb-like with sharp teeth (see fig. 9). The surfaces are convex, and netted with projecting lines of spiny teeth. The *seed* (figs. 8 and 9) is reniform; the hilum is round and situated on the upper third of one of the margins.

Cultivated varieties.

Varieties. Two varieties are in cultivation: —

1. Common or small-seeded Sainfoin, *Onobrychis sativa* var. *communis,* Ahlefeld;
2. Large-seeded Sainfoin, which yields two cuttings, *Onobrychis sativa* var. *bifera,* Hort.

The second variety flowers earlier, its growth is more luxuriant, and the second cutting produces flowering stems. It is, at the present time, less extensively cultivated than formerly; and does not appear to have any advantage over the first variety. Some state that it does not give a large yield because it is in flower all the year round. A third variety, which gives three cuttings, is distinguished in England. This variety, grown at Proskau in Silesia, in a clay soil with a sub-soil of clay-marl, yielded 5368 lbs. of hay per acre in two cuttings.

Wild varieties.

Wild sainfoin is less luxuriant in its growth and has a more downy fruit than the cultivated varieties. An alpine form *(Onobrychis montana* D. C.) is known. Its low spreading stems, darker coloured flowers, keel longer than the standard, wings longer than the calyx-teeth, and short broad leaflets distinguish this from the cultivated varieties.

Name.

The name Sainfoin is derived from the French; it was formerly written Sain foin or Saint foin. The name means hay of health or holy hay.

History.

Sainfoin has not been so long in cultivation as was formerly supposed. The ancient Greeks were not acquainted with it, and, even now, it is not grown in Greece. The plant designated by *Dioscorides* and *Pliny* as *Onobrychis* is not Sainfoin, but a different species viz. *Onobrychis caput galli,* which occurs wild in Greece and other countries, but is not cultivated there. The cultivation of sainfoin probably commenced about the fifteenth century in France, where, in the sixteenth century, it was greatly esteemed. Its cultivation spread into Italy, especially Tuscany, in the eightenth century. In Switzerland, its cultivation commenced about the beginning of last century; the seed was probably obtained from Dauphiny. In 1760, a writer in the Agricultural Gazette of Berne says: »Of fodder plants which are cultivated from seed, the commonest is now the sainfoin called in latin *Onobrychis foliis viciæ.*« To show its grea utility, the same writer gives the following example. »Since the people in the commune of Kappelen near Aarberg, have taken up the cultivation of sainfoin to remedy their great want of fodder, both man and beast, house and field, and even the whole village, have assumed quite a different appearance.« In 1762, *Stapfer* writes: »Another artificial grass, which is now cultivated, is sainfoin«. From, Flanders and France, Sainfoin was brought to England in the seventeenth century. In 1716, Sainfoin was regarded as a very important fodder-plant in Germany, and its cultivation was repeatedly recommended by the government. *David Möllinger* had the honour of introducing it into the Palatinate.

Agricultural value.

By the cultivation of sainfoin, it is possible, to utilise large tracts of land, which, formerly, were almost valueless. It is the most important fodder-plant for dry and barren calcareous hills. It withstands extreme drought, thrives without manure, and is of longt duration. *Lawson* states that he has known it attain the age of 100 years. It is not rare to see fields of Sainfoin 20 years old, which, even now, are doing well. The duration depends very much upon the nature of the soil. In the Palatinate, sainfoin is only used for three years, but, in other parts, usually for periods varying from four to seven years. It must not recur too frequently on the same field because the land becomes »sainfoin-sick«, in the same way as it becomes »clover-sick«. The former is not nearly so common as »clover-sickness«, because the root-system of sainfoin is more extensive, and takes in more ground than that of red-clover. To prevent »sainfoin-sickness« the land requires a period of rest, equal, in a general way, to the period under sainfoin. Some authorities state that the intervals should be 8, 10 or even 12 years, according to the nature of the subsoil, shorter when the subsoil is rich, longer when it is poor.

Geographical distribution.

Occurrence, climate, soil, manure. Sainfoin is indigenous to the temperate regions of *Europe*, to southern Caucasus, the borders of the Caspian Sea, and Lake Baikal; it is not indigenous to Sicily, Sardinia, or Algeria; it is extensively cultivated in Southern France, Jura, Alsace, the Palatinate, the Black Forest, the mountains of Central Germany, Moravia, etc.

Habitat.

In Switzerland, the wild plant is met with on sunny hills, on dry mountain-sides, on the margins of woods, indeed, wherever the soil is calcareous.

Limits of altitude.

On lower Engadine, it occurs at a height of 5250 ft. *(Müller)*. The alpine form *(Onobrychis montana.* DC.) occurs at high altitudes on the Alps (Melchalp 6800 ft. according to *Brügger*, Gantrisch 6800 ft.)

Climate.

Sainfoin is most successful in the vine region. It also thrives in the colder parts, and even in districts with a raw climate, e. g. the hills around Lucerne, the Black Forest, etc. With dry and warm exposure, it lasts longer, and gives a larger yield than on high lands exposed to the north. When young, it is liable to be killed during the winter if not protected. Cutting should therefore take place about the beginning of autumn. Old sainfoin is little affected by winter; a wet, and cold summer does it more injury, the yield being diminished, and a number of the plants perishing. Drought has no injurious action.

Soil.

The nature of the subsoil is very important in this case, because the roots penetrate twice or thrice as deeply as those of lucerne. If the subsoil is favorable, sainfoin succeeds however bad the surface layers may be. To allow the roots an easy entrance, the subsoil should be sufficiently loose, and free from water. Formerly, it was supposed that the success of sainfoin depended upon the presence of a high proportion of lime in the soil. That is, however, not the case, as it thrives quite well on a soil containing only one-half per cent of lime, provided that the other conditions are suitable. It has been stated that the produce increases as the proportion of lime rises, and is at its maximum when twelve per cent of lime is present. The reason why calcareous and marly soils are most suitable for sainfoin, is simply this, that they satisfy the *physical conditions* better than other kinds. It can be grown on calcareous rocks with a superficial soil a few inches thick, provided that there are clefts and fissures in the rock. The tap root enters, and enlarges the fissure. Lateral roots spring from the tap root; these run out in all directions, and interlace among the fragments of the rock. Growing in this way, sainfoin succeeds on the chalk districts of France and England, which would otherwise be unproductive. It thrives also on the alluvial hills of Northern Germany, where a few inches of mud rest upon the sand beneath. Sandy soils with a marly subsoil are also appropriate. On clays it can only be successfully grown, when the subsoil is permeable. Wherever the subsoil retains water, as on moors and bogs, it cannot grow. Calcareous soils with a dry subsoil and exposed to the sun, are the most suitable.

Substances removed from the soil.

1000 lbs. of Sainfoin hay, according to *Wolff*, remove from the soil: —

Nitrogen . . .	21.9 lbs.	Lime	17.3 lbs.
Phosphoric Acid .	4.7 ,,	Magnesia . . .	3.1 ,,
Potash	13.4 ,,	Sulphuric Acid .	1.4 ,,
Silica	1.5 ,,	Soda	3.8 ,,

This analysis shews that sainfoin requires much nitrogen, potash and lime, especially from the subsoil; it tends however to enrich the more superficial layers of soil by drawing stores from the lower layers and leaving residues of roots and leaves in the surface soil on its decay.

Growth.

Growth, yield, nutritive value. The stems are more or less erect, producing many branches and abundant foliage. A plant in full flower, has, on an average, 2074 leaflets, according to *Werner's* calculation. A stem which has been cut or bitten, dies down to a depth of about two inches below the surface. At that depth, a thickening is formed from which two or three new branches spring.

Development.

Development is comparatively slow. The yield, in the first year, is small; in the second, good; but, in the third year, when the roots have attained a depth of from three to seven feet, the maximum yield is obtained. The first crop is ready for cutting about the same time as lucerne. Flowering occurs from the end of May, till the beginning of June. After the first cutting, common sainfoin produces long leaves, but no stems; the produce of aftermath is, therefore, small.

Harvesting.

Sainfoin is usually mown once. Cutting commences when the plant is in full flower, because, at this stage, the nutritive value is highest, and soon after diminishes. Flowering is completed in about eight days, and so there is little choice of harvest-time. Hay-making is easy, since sainfoin dries more readily than red-clover, and the leaflets do not so readily fall away. It is cut like red-clover, and left in the swathe to dry. It is turned as little as possible, to avoid loss of leaf. It does not stand frequent cutting or depasturing since it has not the property, possessed by clovers, of immediately sending out new shoots. Frequent cutting thus brings about the death of the plant. For this reason also depasturing by sheep is very bad. Sainfoin is not suitable for green fodder, and, at any rate, it could only be obtained green during a very small part of the summer. The first crop is good, but the after growth is scarcely sufficient to allow a second mowing.

Yield.

The yield is certain, though not abundant. *Block* reckons that nine good harvests may be obtained in ten years. *Sprengel* estimates the yield of hay at 3520—5280 lbs. per acre. *A. Young* estimates the yield in England at 2816—4784—4664 lbs. *Crud* gives 1320—1760 lbs. In the Palatinate, the produce obtained by *Möllinger,* was 5980 lbs., but the average of 10 years was only 3256 lbs., while that of red-clover was 3860 lbs. According to *Langethal,* the produce varies from 2640 to 5280 lbs.: according to *Guido Krafft* from 1760 to 3800 lbs. *Count Arnim* of Lippe obtained from a good soil 6160 lbs.; *Werner* obtained 2640 to 3520 lbs. and *Häni,* 4270 to 4900 lbs. All these figures refer to the acre.

Nutritive value.

The quality of the fodder is better than that of red-clover.

According to *Wolff,* 100 lbs. of sainfoin-hay contain: —

Organic matter	79.6 lbs., composed of: —		
Albumin (N × 6.25) . .	13.7 ,,	portion digested	7.8 lbs.
Fibre	27.9 ,,	,, ,,	36.9 ,,
Non-nitrogenous extractives	35.3 ,,		
Fat	2.6 ,,	,, ,,	1.4 ,,

Ratio of nitrogenous to non-nitrogenous nutriment 1 : 5.2.

The hay is not only nutritive but very healthy, as indicated by the name sainfoin. It is specially excellent for horses.

Seed-harvest.

Harvesting, impurities and adulteration of seed. In dry climates, and in districts where land is cheap, a seed crop is very profitable. In other circumstances, it is more advisable to use it as fodder. Old fields of sainfoin, which have soon to be broken up, may, with advantage, be used for seed production. If allowed to ripen, and then cut, the plants are very much injured, so much so that a young crop if used for seed would be destroyed. The seed is mature about the end of July. The pods have then a bright brown colour, and the seeds, a cheesy consistence. Later, the pods become deeper brown, and readily fall off, so that, if the crop is allowed to reach this stage, loss ensues. If cut too early, the seed shrivels up, and the germination is low.

The loss is minimised by threshing on cloths spread on the field. When the hay has been put into cock before threshing and has become heated, the seeds lose their germinating power, and become useless. For this reason threshing should at once be proceeded with, or the hay should be spread out and not made into cock. Further procedure is the same as for red-clover seed.

Yield of seed.

A. Young estimates the yield of seed, in Suffolk, at 400 to 550 lbs. per acre; other observers give up to 1100 lbs. *Sprengel* gives 264—460 lbs., *Guido Krafft,* 570—880 lbs., *Häni,* 460 to 920 lbs. per acre.

Impurities.

Burnet (*Poterium sanguisorba,* L., fig. 42) is a frequent impurity, not an adulterant of sainfoin. The fruit is reddish-brown like that of sainfoin. The following numbers show the prevalence of this impurity in the samples analysed at the Swiss control-station: —

1877/78 . .	64.5 %	of the samples contained burnet.
1878/79 . .	43.8 %	
1879/80 . .	49.5 %	
1880/81 . .	34.1 %	
1881/82 . .	34.1 %	

This impurity is very common in French sainfoin, and in the field can cause great damage. It is frequently cleaned out and sold separately. Troublesome impurities, which can, however, be readily removed, are the brome grasses, viz. barren brome *(Bromus sterilis)*, and soft brome *(Bromus mollis,* fig. 43). Corn crowfoot (*Ranunculus arvensis)* and pods of trefoil *(Medicago lupulina* fig. 44) very frequently occur. Alsatian sainfoin often contains 20 % or more of these impurities; farmers buy such seed, and sow it, apparently never thinking that it ought to have been cleaned.

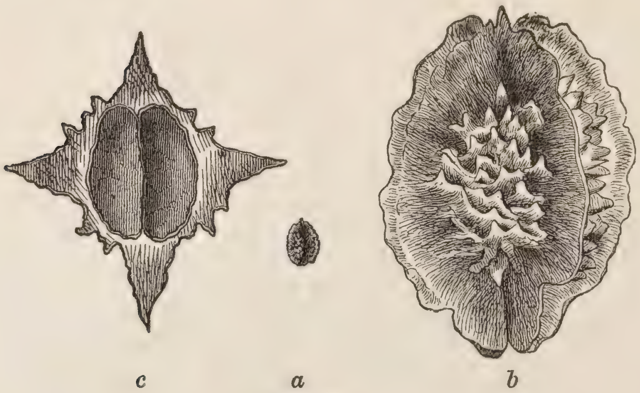

Fig. 42.
Burnet.
Poterium sanguisorba, L.
False fruit.
a. Natural size;
b. × 7;
c. transverse section.

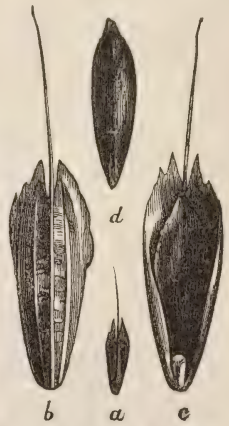

Fig. 43 (after Nobbe.)
Soft Brome.
Bromus mollis, L.
a. False fruit, natural size;
b. the same, magnified, shewing the outer pale;
c. the same, magnified, shewing the inner pale, and the stalk;
d. the caryopsis, magnified.

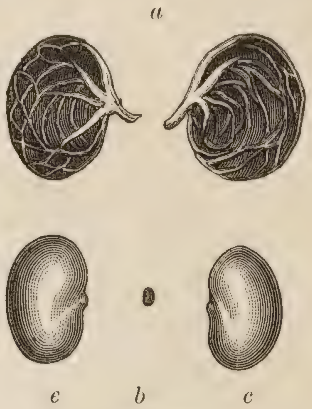

Fig. 44.
Trefoil.
Medicago lupulina, L.
a. Pod with persistent calyx × 7;
b. seed, natural size;
c. seed, × 7.

Adulterations. Adulteration of sainfoin seed is rare.

Seed quality. **Seed and amounts to be sown.** Of 400 samples analysed at the Zurich seed station, the average purity was 95.3 %, and the germination 71 %. Good commercial seed should have 98 % purity, and 80 % germination = 78.4 % of pure and germinating seed. One lb. of pure seed contains, on an average, 22,500 grains, therefore 1000 seeds weigh about 310 grains. The weight per bushel is 40 lbs. on an average, but may be much greater if the seed is very good. Good seeds should be large, plump, bright in colour, and readily crushed between the teeth. When kept, the germination rapidly diminishes, and if the seed lies for a year, it becomes dark, hard, and shrivelled, and is of no use.

Quantity to be sown. An acre requires 78 lbs. of unshelled seed containing 78 % pure and germinating = 60.84 lbs. of pure and germinating seed. Although not usual with fodder-plants, it is advantageous to sow sainfoin with the drill, because it is then more regularly buried and germinates better. If sown broadcast, and dry weather sets in, only a small proportion of the plants manage to pierce the pod: the greater number are imprisoned and die. If the pod has been removed i.e. if milled seed is used, the germination is quicker, more certain, and more uniform. Shelling or milling is difficult, because the pericarp is very tough, and the seed brittle. Milled seed can be obtained in commerce, and, if of good quality, should be preferred. Half the quantity of milled seed should be used per acre.

Sowing.

It is the custom to sow sainfoin by itself. The preceding crop should leave the field loose, clean, and well manured. However sainfoin is not very particular, and if these conditions are not fulfilled, a good preparation of the land will be sufficient. Spring sowing from the end of March till the beginning of May is best. Autumn sowing is rarely practised. It may be sown with a cereal crop. The safest plan is to sow without a protective crop or with a crop to be cut green e. g. green oats or green rye. It may, however be sown in a spring or a winter cereal, with good results in a dry season. If the season is wet, the cereal is laid, and the young sainfoin plants are liable to be injured. A spring cereal is a better protective crop than a winter cereal. Spring wheat is specially appropriate. The seed should be covered by about an inch of soil.

Sainfoin is rarely mixed with other fodder-plants, because it is then liable to be destroyed. Sainfoin and lucerne, when sown with red-clover, are said to prevent the outbreak of dodder. When the soil is suitable, sainfoin can be added to clover-grass, to form mixtures for temporary or permanent leys.

Allied species.

A fodder-plant closely allied to this is Spanish sainfoin (*Onobrychis coronaria*) which has lately come into cultivation in Southern Europe.

XVIII. Various-leaved fescue.

Festuca heterophylla, Lam. (not Hænke).
Festuca rubra, subsp. *heterophylla*, Hackel.

Explanation of plate.

Fig. A. Entire plant in flower; the panicle spreading.
,, B. Panicle contracted, before flowering.
,, 1. A five-flowered spikelet, in flower. The stamens and stigmas are seen projecting from the lowest flower.
,, 2. A five-flowered spikelet, before flowering.
,, 3. False fruit, ventral surface.
,, 4. False fruit, dorsal surface.
,, 5. False fruit, side-view.
,, 6. Caryopsis, dorsal surface.
,, 7. Caryopsis, ventral surface.
,, 8. Caryopsis, side-view.
,, 9. Transverse section of a young shoot shewing the entire leaf-sheath and the folded blade.
,, 10. Transverse section of the blade of a culm leaf.
,, 11. The ligule.

Botanical description.

Botanical description. Various-leaved fescue is distinguished from creeping fescue and tufted fescue by this peculiarity in its growth, viz. that the intravaginal shoots are much more numerous, than the extravaginal. The *tuft* is quite compact as none of the shoots have a creeping character.

The *culm* is smooth, 2 to 4 ft. high, and has three nodes. The *leaf-sheath* is entire (fig. 9). The *leaf-blades* of the barren shoots, corresponding to those of the radical leaves, are very long, soft, permanently folded and bristle-like (setaceous). The transverse section is triangular; beneath the epidermis of the outer surface, at the angles, lie isolated bundles of hard bast (the dark parts in fig. 9). On the culms, the blades unfold and, accordingly, lose their setaceous character, becoming flat, and 2 to 3 mm. broad. The upper surface is hairy, and has from 5 to 17 well marked ribs. The furrows are occupied by »bulliform cells« (fig. 10). Each of the vascular bundles corresponding to the broader ribs is surrounded by a ring of hard bast which is extended both to the upper and lower surfaces of the blade. — To each of the smaller and narrower ribs corresponds a small vascular bundle; directly above and below these, but quite separate from them, lie small bundles of hard bast (fig. 10). The *ligule* is reduced to a mere border, which is almost earless (fig. 11).

The *panicle* is large and loose, often nodding at the apex; its length varies from 2 to 6 inches (fig. A). The spikelet is three- to nine-flowered, and varies in length from 8 to 10 mm. The awns are half as long, or, at times, as long as the pales which bear them, and upwards rough (figs. 1 to 5). The *ovary* is covered with soft hairs.

The *false fruit* is slender and 4.5 to 5.5 mm. long, not including the awn. The stalk is downy and almost half as long as the fruit (figs. 3 to 5). The flat *caryopsis* is 3.5 to 4.5 mm. long; it has a shallow groove and a long hilum on the ventral surface (figs. 6 to 8).

Varieties.

Varieties. Several varieties of this plant are in cultivation in England. The following deserve mention: 1. *precox* (an early variety); 2. *purpurata* (a purple variety); 3. *serratifolia* (a variety with serrated leaf-blades); and 4. *glabra* (a hairless variety). Speaking of various-leaved fescue, *Hackel* states that it does not grow further north than 52° north latitude; as he does not mention it as indigenous to England, it is very probable that the four varieties mentioned above are in reality forms of tufted red fescue (*Festuca rubra fallax*, Hackel). The tufted red fescues are often regarded as varieties of various-leaved fescue.

Name.

Linnæus, in the twelfth edition of his »*Systema naturæ*«, 1767, designated various-leaved fescue as *Festuca duriuscula*. In the tenth edition, 1759, and in the second edition of his »*Species plantarum*«, he designated hard sheep's fescue as *Festuca duriuscula*. This change of name has led to much confusion and error. To avoid mistakes the name *duriuscula* should not be applied to various-leaved fescue (*Festuca heterophylla*, Lam.).

Agricultural value.

Sprengel's attention was early directed to this grass and he experimentally determined some of its properties. Trials have also been made upon it at the Swiss station, and the results have proved very satisfactory. Several authorities state that it grows better on shady than on exposed situations. In the latter case, it continues to live, but, as *Langethal* has pointed out, its produce gradually diminishes.

Geographical distribution.

Occurrence, climate, soil, manure. Various-leaved fescue is, in the main, a southern plant. It does not extend further than 52° north latitude. In *France*, it occurs as far north as Paris. It also occurs throughout Italy, Western and Southern Germany. The northern limit, according to *Hackel*, is the Palatinate, Bonn, Kyffhäuser, Brunswick, Sondershausen, Halle, Spandau, Strehlen. It is rare in the Swiss plains, also in Austria, Bosnia, Servia and Macedonia. In *Asia*, it occurs in the Caucasus and the Himalayan regions.

Habitat.

It is met with in woods, usually on their borders, or on spots to which light has access.

Limits of altitude.

The limits of altitude correspond to the geographical distribution in a northern direction. Cultivation at high altitudes does not give good results. In such districts, its place can be taken by tufted red fescue.

Climate.

On suitable soil, it is little affected by climatic influences, and it can withstand extreme drought.

Soil.

It thrives best on low-lying land which is moist and contains humus, on loamy sands, and on sandy loams. On poor sands it does not thrive, but on good moorlands it does better.

Substances removed from the soil.

According to the Swiss experiments, 1000 lbs. of hay remove from the soil: —

Nitrogen	8.7 lbs.	Magnesia . . .	0.3 lbs.
Phosphoric acid .	10.7 „	Lime	2.5 „
Potash	14.1 „	Silica	44.0 „
Soda	0.6 „	Sulphuric acid . .	1.9 „

The ash is therefore rich in Phosphoric acid and Silica.

Growth.

Growth, yield, nutritive value. Various-leaved fescue forms compact tufts of long, bristle-like radical leaves: these form bottom grass. The culms are less numerous; they reach a height of about 3 feet. On the culms, the leaves open out and are thus much broader than the others (hence the name *heterophylla*); they represent top-grass. When old, the tufts frequently form cushions several inches high and thus produce a very uneven surface.

Development.

Development is similar to that of *Festuca rubra*, and, accordingly, the maximum yield is obtained in the second year. In spring, it is somewhat later than *Festuca rubra*, and the aftermath is smaller.

Yield.

Vianne obtained 4,100 lbs. of hay per acre.

Nutritive value.

According to the Swiss experiments, 100 lbs. of hay cut on the 13th June contained:
Organic matter 77.9 %, composed of: —

Nitrogenous matter (N × 6.25)	5.5 %
(Albuminoid N. 0.567 %, non-albuminoid N. 0.309 %)	
Fat	2.8 %
Fibre	38.9 %
Non-nitrogenous extractives	30.7 %

The amount of albumin is thus less than in hay of medium quality, but the amount of fat is slightly higher. *Way* analysed various-leaved fescue; it is, however, impossible to decide whether his analyses refer to this grass or to tufted fescue (*Festuca fallax*).

Seed harvest.

Harvesting, impurities and adulteration of seed. Seed for purposes of commerce is, like that of creeping red fescue, collected in woods. Its preparation is also similar.

Impurities and Adulterations.

Commercial seed is rarely genuine. *Festuca fallax* is usually substituted for it. Genuine seed, may be obtained from Vilmorin-Andrieux & Co. of Paris, Lecoq & Co. of Darmstadt, and Schärly & Felber of Willisau.

Adulteration.

At times it is adulterated with mouse tail (*Vulpia bromoides* fig. 45); this seed is much narrower and has a longer awn.

Seed and amount to be sown.

The average purity is 92.7 %, and the germination 63 % = 58.4 % of pure and germinating seed. The number of seeds per lb. varies from 350,000 to 545,000 grains. One acre of ground requires 33½ lbs. of seed containing 58.4 % pure and germinating = 19.5 lbs. of pure and germinating seed.

Sowing.

Pure sowing is not advisable because the tufted mode of growth is incompatible with the formation of a complete sward. Smooth-stalked meadow grass mixed with it fills up the gaps.

Gardeners use various-leaved fescue for borders, etc.

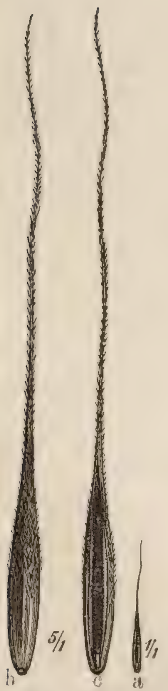

Fig. 45.
Vulpia bromoides, Link.
a. False fruit, natural size;
b. the same, dorsal surface;
c. the same, ventral surface × 5.

Tufted red fescue.

Festuca fallax, Thuill. *Festuca rubra,* subsp. *eu-rubra,* var. *fallax,* Hackel.
(*Festuca heterophylla,* Hæncke).

This fescue is, as its name indicates, distinguished from creeping red fescue by its mode of growth. In both cases, the extravaginal shoots are more numerous than the intravaginal and in this respect, creeping and tufted fescues differ from *Festuca heterophylla.* The shoots do not creep, but ascend directly above ground, accordingly all the aerial branches stand close alongside one-another, and form a compact tuft. This fescue cannot therefore make a complete sward, as bare spaces must occur between the tufts. Although closely allied to creeping red fescue, it should, from an agricultural standpoint, be classed with various-leaved fescue, as its cultivation is much the same. In distribution it agrees with creeping red fescue, but is much rarer. An alpine variety (*nigrescens,* Lam.) occurs on the Pyrennees, Alps (Wollerau 1970 ft., St. Bernardine 5800—6880 ft., Rothhorn of Parpan 6880 ft., Ralligstöcke, Engstlenalp, Stockhorn, Gemmi), Jura, Central France and Calabria. It is more suitable for exposed situations than various-leaved fescue. In commerce, the seed is sold either as creeping red fescue or as various-leaved fescue.

Alpine red fescue*).

Festuca violacea, Gaudin.
Festuca rubra, subspecies *violacea,* Hackel.

In its tufted growth and pubescent ovary this agrees with various-leaved fescue. It is distinguished by the predominance of the extra-vaginal shoots, by the culm leaves which are permanently folded and bristle-like, and by the spikelets which are larger and have a violet tint (hence the name). It is found on the Alps and Jura. Nothing is known concerning its agricultural value*).

XIX. Alpine meadow-grass.

Poa alpina, L.

Explanation of plate.

Fig. A. The common variety. Entire plant in flower.
,, B. The viviparous variety. The panicle.
,, 1. The common variety. A six-flowered spikelet.
,, 2. The same. A pair of pales.
,, 3. The same. The upper pale detached.
,, 4. The same. The false-fruit, side-view.
,, 5. The same. The false-fruit, ventral view.
,, 6. The same. The caryopsis, side-view.
,, 7. The viviparous variety. A spikelet; the two glumes and the lower pale of the first flower are unchanged, the lower pale of the second flower is partially metamorphosed; the lower pales of the third, fourth and fifth flowers are completely metamorphosed into the foliage leaves of a bulbil and conceal the terminal bud and other smaller leaves.
,, 8. The basal part of the same spikelet with two glumes and the lower pale of the first flower removed. To the left, the metamorphosed lower pale of the second flower is shewn, the apical part has been cut away and the remainder pulled down so as to lay bare the upper pale and flower which are situated in its axil.

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*) See *Stebler*'s and *Schröter*'s work on Alpine fodder-plants.

Fig. 9. The lowest leaf of the bulbil (corresponding to the lower pale of the third flower); its sheath is laid open to shew the upper pale which is normal (behind it is a rudimentary flower).

„ 10—14. Successive transitions between the normal lower pale and foliage leaf.

„ 10. The pale lengthening and beginning to bend inwards at the apex, anastomoses forming between the longitudinal veins, and reduction of the hairs.

„ 11. Apex more strongly curved, and the hair quite gone. At the base, a rootlet is beginning to develope. This figure represents the apical pale of a spikelet which is slightly viviparous.

„ 12. Sheath and blade are becoming differentiated. At *a* to the left and at *b* to the right the ligule is beginning to be formed.

„ 13. A metamorphosed spikelet, the glumes removed. To the left, the lower pale of the second flower is distinctly metamorphosed into the sheath and blade of a foliage leaf, but the hair has not yet disappeared from the back.

„ 14. The pale represented in the previous figure, more highly magnified. *b.* ventral view. *c.* side-view.

„ 15. A lower pale almost transformed into a foliage leaf, side-view. It bears an upper pale and a flower in its axil.

„ 16. The upper pale and flower removed from the axil of the preceding figure.

„ 17 and 18. The metamorphosed spikelet, side-view, natural size.

„ 19. A spikelet at the commencement of metamorphosis, the parts detached, side-view.

„ 20. Transverse section of a young leafy branch showing: two sheaths, the outer cut near the apex and split, the inner cut lower down and entire, and two folded leaf blades.

„ 21. Transverse section of a leaf blade.

„ 22. The ligule of a culm leaf and the split apex of its sheath.

Botanical description.

Botanical description. Alpine meadow-grass forms a simple, compact tuft of grass. All the branches are intravaginal and closely enveloped by the old persistent leaf-sheaths. Hence the compactness of the tuft and the bulbous appearance presented by the base of the plant (fig. A.) In this case, however, the bases of the leaves are not thickened as in an ordinary bulb. All the branches lie in one plane and the tuft is accordingly flat on the sides. Stolons are never produced. The *culm* bears very few leaves, it is smooth and from 12 to 18 inches in height.

The *leaf-sheath* is entire for the greater part of its length (fig. 20). The sheaths of the radical leaves persist for a long time becoming, when old, dry membranes, enveloping the younger leaves and branches. The *leaf-blade* is short, but broad and sharply tapered off at the apex. The transverse section usually shews four or five principal veins (vascular bundles) on each side of the midrib; weaker veins lie between. Bundles of bast are found beneath the epidermis, both above and below the principal veins, but always isolated from them (fig. 21). The *ligule* of the radical leaves is a mere margin; that of the culm leaves is longer and acute (fig. 22).

The *inflorescence* is a panicle with many branches which are widely spread during flowering. The *spikelets* vary considerably. The common variety *(Poa alpina,* var. *vulgaris,* fig. A) has normal spikelets; each contains from four to six (fig. 1), rarely eight flowers; the pales are green, variegated with bronze, brown or violet tints. The *glumes* are delicate membranes, three-ribbed, and slightly rough on the keel (fig. 1). The *lower pale* has five ribs (one dorsal, two lateral and two marginal), and certain parts are covered with long hair (fig. 2). The hairs occur along the dorsal rib and the lower part of the marginal ribs, but the lateral ribs have little or none. These hairs do not interlace and form webs like the »*lana conjunctiva*« so characteristic of the smooth-stalked and rough-stalked meadow-grasses *(Poa pratensis* and *Poa trivialis).* The hairs here are shorter, stiffer and have less tendency to curl than the »*webs*« of the Poas just mentioned. These structural differences correspond to a difference in function. In *Poa pratensis, trivialis* and some other species, the hairs on the pales serve to attach the false-fruits to passing animals. The rigid, spreading hairs of *Poa alpina,* on the other hand, increase the surface and thus serve as wings which allow the false-fruits to be acted upon and distributed by the wind.

The upper pale like the lower possesses hair on both its keels, especially at the base, a peculiarity remarkably rare (fig. 3).

The *false-fruit* varies in length from 3 to 3.5 mm. Its hair has just been described. The *stalk* is obliquely truncate (fig. 4).

The *caryopsis* varies from 1.5 to 2 mm. in length. It is triangular and the ventral surface is slightly concave (fig. 6).

Botanical description of the viviparous variety.

On the Alps, the viviparous variety is more abundant than the normal. The spikelets form young plants instead of producing seed.

The axis of the spikelet is transformed directly into the axis of the young plant and certain pales become the foliage leaves*). In this way, the spikelet is metamorphosed into a bud (bulbil) which later on detaches, strikes root in the ground and developes a new plant. This metamorphosis of the spikelet is quite different from a phenomenon frequently observed in cereal grasses. The seeds of the cereal germinate and develope into a young plant while they are still in the ear. In the viviparous *Poa*. the young plant is not at all formed from a seed, but, by the metamorphosis of a spikelet, which is virtually a bud, into a young plant. This is a case of non-sexual multiplication closely analogous to the non-sexual multiplication of onions by axillary bulbils and of potatoes by their tubers.

In the same panicle, all gradations between the normally developed pale and the green leaf into which it is metamorphosed may be readily observed in different spikelets. The glumes and the lower pale of the first flower never undergo metamorphosis; the first flower along with its upper pale is also normal and fertile (figs. 7 to 9).

The lower pale of the second flower is either partially or completely metamorphosed into a green leaf; it becomes abnormally long, the apex bends inwards, towards the axis of the spikelets, the longitudinal veins increase in number, transverse and anastomosing veinlets become developed, and the hairs disappear; sheath, blade and ligule become differentiated and the foliage leaf is perfect (figs. 10 to 11; see also explanation of plate). The flower and upper pale produced in the axil of this lower pale are always normal.

The lower pale of the third flower is sometimes partially, but usually completely metamorphosed. In its axil, a leaf bud is sometimes produced instead of a flower. The rest of the spikelet is usually completely metamorphosed. The metamorphosed part of the spikelet above the second leaf easily detaches as a whole and usually consists of two or three leaves. At a very early period the roots develope at the base (fig. 11).

Name.

In Switzerland Alpine meadow-grass is variously named: Wild-grass, Bulbous-rooted grass, etc.

Agricultural value.

This grass, along with tufted red fescue *(Festuca rubra* var. *fallax* forma *nigrescens)*, *Meum Mutellina*, Gærtner, and alpine plantain *(Plantago alpina*, L.) often constitutes a very essential part of alpine pastures. Its high nutritive value should be sufficient recommendation for any pasture in a mountainous district.

Varieties.

Varieties. Five varieties are distinguished: 1. Viviparous Alpine meadow-grass, *Poa alpina vivipara*. The spikelets are metamorphosed into leaf buds. 2. Common Alpine meadow-grass, *Poa alpina vulgaris*. This is similar to the preceding, but the spikelets are normal. 3. *Poa alpina badensis*. The leaves are short and cartilaginous on the margins. 4. *Poa alpina brevifolia*. This is similar to the preceding. 5. *Poa alpina frigida*. This is a diminutive form found on the high Alps. Of these, *Poa alpina vivipara* and *Poa alpina vulgaris* are alone of agricultural importance.

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*) *A. B. Frank* in his Handbook «The Diseases of plants» states on page 251 that the bulbil of *Poa alpina, laxa* and *minor* corresponds to a flower; fig. 51 represents a spikelet with the upper pales rudimentary. In a written communication (which I am authorised to use) he states that further examination has convinced him that my statement in the text above is correct, and that the rudimentary pales so called in fig. 51 of his work are in reality rootlets.

Geographical distribution.

Occurrence, climate, soil, manure. Alpine meadow-grass is found in the arctic zone and the alpine regions of most mountainous districts in the temperate zone of the northern hemisphere (Sierra Nevada, Pyrenees, Jura, Vosges, Black Forest, Alps, Carpathians, Apennines, Ural, Caucasus, Altai, Himalayan and Rocky Mountains).

Habitat.

The viviparous variety is very common in Alpine pastures where the soil is moist and rich, on rocky slopes, in wood clearings and by mountain roadsides.

Limits of altitude.

It has been found at the following altitudes: — Stilfserjoch 8,450 ft., Torrenthorn 7,850 to 8,850 ft., the Muretto Pass 5,900 to 6,900 ft., Tschirtschen 4,400 ft., Bavarian Alps 3,900 to 7,300 ft., Auvergne 6,200 ft., Pyrenees 6,500 ft., Vignemal 9,800 ft., Caucasus 9,800 ft. It is carried by torrents and rivers into the valleys and plains. (Wolfsschlucht in the valley of the Töss 2,450 ft., Wimmis 2,250 ft., Nettstall 1,450 ft., Weinfelden on the Thur 1,450 ft.)

Climate.

This grass requires a moist atmosphere, and in winter, a snowy covering to protect it from the frost. These conditions are attained on the Alps where the snow persists during the winter and protects the grass. It cannot live in localities dried up by the summer sun.

Soil.

It succeeds best on rich, moist soils which are light and calcareous, even though somewhat shallow.

Substances removed from the soil.

1000 lbs. of hay remove from the soil: —

Nitrogen	16.9 lbs.	Lime	8.1 lbs.
Phosphoric acid . .	14.1 ,,	Magnesia	4.8 ,,
Potash	36.0 ,,	Sulphuric acid . .	5.0 ,,
Soda	2.3 ,,	Silica	43.1 ,,

Manure.

A rich, old soil is preferable to one recently manured. To counteract the drying action of the sun, irrigation is resorted to, even in mountainous districts, as, for example, in Valais.

Growth.

Growth, yield, nutritive value. The plant is formed of a tuft of branches compacted together. The radical leaves are large, numerous and surrounded by leaf sheaths. The culms produced are few and vary in height from ten to eighteen inches. The spikelets of the viviparous variety, which is the most abundant on the Alps, do not produce flowers but small leaf buds (bulbils) which in moist districts soon grow up and become small plants. By the weight of these bulbils, the culm is gradually bent down and ultimately comes to lie upon the ground. The buds soon strike their roots into the moist soil with which they are in contact, separate from the parent and develope into independent plants.

Even while the culms are still erect, the buds often fall off and strike root.

Development.

During the first year, the plants produced in this way always remain small and develope few leaves. During the second year, culms and bulbils are produced. These, in their turn, if they are not destroyed by browsing cattle, develope a new generation of plants. The former fate usually awaits them on those parts of the pasture accessible to animals, the delicate buds being very tasty and nutritious.

Yield.

Sinclair obtained from common Alpine meadow-grass, the seed-producing variety grown on a light sandy loam, 1700 lbs. of hay per acre. The yield is thus seen to be small.

Nutritive value.

As fodder, this is a very nutritious grass as shewn by the analysis of its hay, made at the Swiss station.

100 lbs. contain: — organic matter 73.1 %, composed of: —

Nitrogenous matter (Nitrogen × 6.25) (albuminoid-nitrogen 1.29 %, non-albuminoid nitrogen 0.404 %)	10.6 %
Fat	3.0 %
Fibre	22.6 %
Non-nitrogenous extractives	36.9 %

This analysis shews that the nutritive value is higher than that of good hay, and it is probable that the plants found growing naturally on the Alps contain even more nutritive matter than those analysed.

Harvesting the seed.

Seed and amount to be sown. By the end of June or the middle of July, the seed is ripe, the culms are then cut and allowed to ripen in the barn; the further treatment is similar to that of smooth-stalked meadow-grass.

Non-sexual reproduction by bulbils.

To reproduce the viviparous variety, the bulbils are simply stripped off and scattered over the ground, On August 2nd 1882 I scattered a handful of such bulbils over a plot of ground 25 feet square in my experimental field. Development soon commenced and by the end of April 1883 culms had been produced. On May 26th the plot was mown and a second crop was obtained during the same year. The plants grew in such abundance as to cover the whole plot.

In mountainous districts this method of reproduction may be followed, and fine pasturage obtained with no expense for seed. This plan succeeds best in mountainous districts with moist atmosphere. The most suitable time for scattering the bulbils is between the middle of May and the beginning of September.

Red fescue.

Festuca rubra, Hackel.

Under this name we understand, with *Hackel,* fescues without bulbous thickening at the base, and with a creeping (stoloniferous) mode of growth; any tufts which they form are loose, rarely compact. The lateral shoots are all or nearly all vaginal. The *leaves* are folded in the bud; when old, they either remain folded and bristle-like or lose the fold and become flat. The leaves of the barren shoots *i. e.* the radical leaves are usually folded permanently, while those of the culm open out and become flat. In rare cases, all the leaves may remain folded or all may become flat. The ligule of the culm-leaves has two ears; the leaf-sheath is complete, and the ovary either glabrous or hairy. The only essential difference between *Festuca rubra* and *Festuca ovina* is the presence of extravaginal branches in the former.

The following varieties of red fescue can be distinguished:

1) Creeping red fescue, *Festuca rubra,* L. (*Festuca rubra,* subsp. *eu-rubra,* var. *genuina,* Hackel).

2) Tufted red fescue, *Festuca fallax,* Thuill. (*Festuca rubra,* subsp. *eu-rubra,* var. *fallax,* Hackel). The term «*fallax*», (deceitful) is applied to this grass because by its tufted growth it simulates sheep's fescue.

3) Various-leaved red fescue, *Festuca heterophylla*, Lamarck. (*Festuca rubra*, subsp. *heterophylla*, Hackel).

4) Alpine red fescue, *Festuca violacea*, Hackel. (*Festuca rubra*, subsp. *violacea*, Hackel Monogr.)

These four varieties are of exceeding importance in agriculture. The first and third are here treated more fully; the second is similar in character and agricultural value to the third. No experiments have as yet been made with the fourth variety. Two other varieties are known, they are:

5) Flat leaved red fescue, *Festuca rubra*, subsp. *eu-rubra*, var. *panifolia*, Hackel, with all the leaf-blades open and flat.

6) Fine-leaved red fescue, *Festuca rubra*, subsp. *eu-rubra*, var. *trichophylla*, Hackel. (*Festuca trichophylla*, Gaud.), with all the leaves folded and bristle-like.

XX. Creeping fescue.

Festuca rubra, L. *Festuca rubra*, subsp. *eu-rubra*, var. *genuina*, Hackel.

Explanation of plate.

Fig. A. Entire plant in flower.
,, 1. Spikelet in flower.
,, 2. False fruit, ventral surface.
,, 3. False fruit, dorsal surface.
,, 4. False fruit, side-view.
,, 5. Caryopsis, ventral surface.
,, 6. Caryopsis, dorsal surface.
,, 7. Caryposis, side-view.
,, 8. Transverse section of the blade and sheath of a young shoot.
,, 9. Transverse section of the blade of a culm-leaf.
,, 10. The ligule of a culm-leaf.

Botanical description.

Botanical description. On the plate, the large-flowered form (sub-var. *grandiflora*, Hackel) of creeping fescue has a loose, stoloniferous mode of growth. The intra-vaginal shoots form small partial tufts. The extra-vaginal branches creep horizontally for variable distances, at times even bending downwards. The whole plant is, therefore, formed of a number of partial tufts, bound together by underground branches (fig. A.) The *culm* is ascending and smooth: it rises to a height of from 18 to 36 inches. The *leaf-sheath* is smooth and entire (fig. 8). The *leaf-blades* of the radical leaves are permanently folded and bristle-like, with 5 to 7 ribs (fig. 9). On the under-surface of the leaf, beneath the epidermis, lie distinct bast-bundles, corresponding in number and position to the veins (fig. 8). The blades of the culm-leaves open out and have numerous veins. The upper surface is hairy with well-marked ribs corresponding to the veins. The epidermis between these ribs is composed of »bulliform cells« (fig. 9). Distinct bundles of bast lie beneath the epidermis, both of the lower and upper surface; here also they correspond in number and position to the veins (fig. 9). The *ligule* is always glabrous; on the leaves of the barren shoots it is reduced to a mere border, while on the culm-leaves it is slightly eared (fig. 10).

On *flowering* the branches of the *panicle* spread widely. The *spikelet* of the sub-var. *grandiflora* is 10 mm. long, in other sub-varities only 7 to 8 mm. Each *spikelet* contains from four to six flowers; the lower pales bear awns (fig. 1). The *ovary* is glabrous. The *false fruit* (figs. 2 to 4) is 3 to 5 mm. long without the awn, and has a glabrous stalk. The length of the *caryopsis* (figs. 5 to 7) varies between 2 and 3.5 mm., it is compressed; the ventral surface shews a broad shallow furrow and a long hilum.

Name.

Creeping red fescue or, shortly, creeping fescue is sometimes called red sheep's fescue. This and the tufted red fescue belong to the genuine red fescues (subspecies *eu-rubra*, Hackel).

History.

Although this grass has only recently come into cultivation, its value was recognised by *Schreber* as early as 1769 and later by *Mauke*.

Agricultural value.

Creeping fescue is perennial, and, on appropriate soil, is valuable either as pasture or as bottom grass, although it does not yield fodder of the best quality. According to *Sinclair*, its duration is from 7 to 8 years. The maximum yield is obtained in the second year. On good soils, better grasses ought to take its place. On poor land, especially moist sands and railway-banks, it forms a compact grass and serves to bind the soil by its subterranean branches. As fodder it is tolerably good. The aerial part of the plant closely resembles hard fescue, but, on the whole, it is more robust

Geographical distribution.

Occurrence, Climate, Soil, Manure. Creeping fescue has a wide distribution in *Europe*, extending from Spitzbergen to Greece, Sicily and Southern Spain. In Southern Europe it occurs only on the high mountains, as on Oeta in Greece, at a height of 6,500 ft. In the Sierra Nevada of Spain, it occurs at an altitude of 9,200 ft. It is also found in the temperate regions of *Asia* and of *N. America*.

Habitat and Limits of altitude.

It occurs on dry pastures, by roadsides, on the margins of woods, in wood-clearings, in sandy fields and even on walls. It extends from the sea level to the alpine regions (St. Moritz 5,900 ft. Piz Padella 7,200 ft., Melchalp 6,850 ft., Rigi 5,900 ft. etc.).

Climate.

Creeping fescue when growing in a favourable soil, is little affected by drought, although it is not so hardy in this respect as sheep's fescue. In general, it delights in dew and can therefore be cultivated on sands by the sea-side, or on the borders of rivers. It is not at all sensitive to cold and bears shade very well.

Soil.

It thrives best on loose, half-moory soil in which the stolons can develope. It can also be grown on shallow soil if it is good and not too dry. In many alpine regions where the layer of soil is extremely thin, it forms the bulk of the pasture, showing that a loose, rich soil, however shallow, is suitable for its growth. In hay grown on light sandy soils, it is often abundant and in such cases it forms very valuable bottom grass; it thrives better than other bottom grasses. It succeeds equally well on the better class of moorlands, but it is out of place on other good soils.

Substances removed from the soil.

According to the experiments made at the Swiss station, 1000 lbs. of hay remove from the soil:

Nitrogen . . .	7.9 lbs.	Magnesia . . .	0.4 lbs.
Phosphoric acid .	9.0 ,,	Lime	3.9 ,,
Potash	11.5 ,,	Silica	32.7 ,,
Soda	0.5 ,,	Sulphuric acid . .	1.8 ,,

Manure.

The root system is confined mainly to the superficial layer of the soil, and from this layer these substances are removed. Accordingly, a top-dressing or irrigation acts very favourably.

Growth.

Growth, yield, nutritive value. Creeping fescue forms a loose tuft of grass with short, creeping, underground branches (see botanical description). This mode of growth enables it to form a complete, though somewhat loose sward.

Development.

During the year of sowing, it developes very little produce, but during the second year the maximum yield is obtained. It shoots somewhat later in spring than sheep's fescue. The flowers appear at the end of May or the beginning of June; at high altitudes, of course, somewhat later. After flowering, the radical leaves become partially dry, and for this reason, the grass should, if possible, be cut before that stage is reached. The aftermath is not great, because it consists only of leaves; it is, however, greater than that of the hard fescue. The leaves of the second cutting remain green till the middle of winter. Depasturing must take place as early as possible, since the grass soon becomes hard and is then avoided by stock.

Yield.

The yield depends greatly on the nature of soil. *Sinclair* obtained from a light sandy soil 10,209 lbs. of grass or 4339 lbs. (38.8 cwt.) of hay per acre. From a rich black sand, incumbent on clay, he obtained from the var. *dumetorum* 5445 lbs. (49 cwt.) of hay per acre. *Vianne* obtained 3300 lbs. (30 cwt.) per acre.

100 lbs. of grass give, according to *Vianne* 42 lbs., according to *Sinclair* 43 lbs. of hay. At the Swiss station, 100 lbs. of hay of *Festuca rubra, eu-rubra, genuina, grandiflora* cut on the 30th of June shortly before flowering, contained 79.1 lbs. of organic matter composed of:

Nitrogenous matter (Nitrogen × 6.25 (albuminoid-nitrogen 0.61 % non-albuminoid nitrogen 0.18 %)	4.9 %
Fat	2.4 %
Fibre	33.5 %
Non-nitrogenous extractives	38.3 %

According to *Ritthausen & Scheven,* it contains 80.4 % organic matter composed of:

Nitrogenous matter	7.8 %
Fat	1.6 %
Fibre	39.2 %
Non-nitrogenous extractives	31.8 %

During and after flowering, the amount of nutriment is thus less than that of hay of medium quality.

Harvesting the seed.

Harvesting, impurities and adulteration of seed. Seed for commercial purposes is not cultivated on a large scale, but gathered from wild plants, which are ready for cutting about the middle of July. When the panicles, have become contracted, the tops of the culms are cut off and allowed to ripen in the barn. The cutting must not be delayed too long because many seeds fall away and are lost.

Impurities and adulteration

Commercial seed labelled *Festuca rubra* cannot be relied upon. Sheep's fescue, various-leaved fescue, and tufted red fescue *(Festuca fallax)* are commonly substituted for it. Creeping fescue is seldom obtained, although the plant itself is not rare. Unfortunately it is very difficult, at times even impossible, to distinguish the seeds of these grasses. The seed of various-leaved fescue is the largest; the long, narrow form, and the pale, gradually tapering off into the awn, are the most characteristic points. It is impossible to distinguish the seed of *tufted* and *creeping* red fescues while those of sheep's fescue are usually shorter (compare the botanical descriptions of the false fruits of these grasses and the drawings on plates XVI, XVIII and XX).

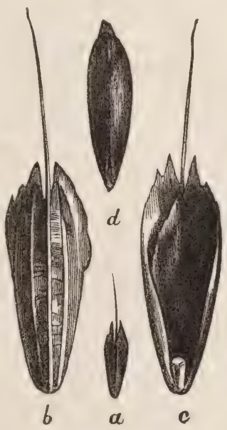

Fig. 46.
Soft Brome.
Bromus mollis, L.
a. False fruit, natural size;
b. the same, magnified, dorsal surface;
c. the same, ventral surface;
d. the caryopsis, magnified.

Under the name of *Festuca dumetorum, Vilmorin-Andrieux & Co.* of Paris supply a seed which was grown and determined by *Hackel* as the var. *grandiflora* of creeping fescue.

Impurities.

The following impurities are met with; soft Brome *(Bromus mollis,* sheep sorrel *(Rumex acetosella)* etc. Wavy hair grass *(Aira flexuosa)* (fig. XX), is distinguished by the basal awn the loose pales which are hairy at the base. The seed of purple melic *Molinia cœrulea* (fig. 40), is distinguished by the absence of the awn and the projecting apex of the upper pale. At times, *Vulpia bromoides* (fig. 41), is used for purposes of adulteration.

Seed quality.

Seed and amounts to be sown. Good average seed should have 85 % purity and 50 % germination = 42.5 % of pure and germinating seed. According to the quality, the weight per bushel varies from 10 to 15 lbs., on an average it is 13 or 14 lbs. According to the variety, one lb. of pure seed contains from 364,000 to 820,000 grains; when the spikelets are large, the number of grains varies from 364,000 to 450,000, but in the common variety up to 820,000. An acre of ground requires 30 lbs. of seed containing 42.5 % pure and germinating = 13 lbs. nearly of pure germinating seed.

By itself this grass gives a very small produce; it should, therefore, always be used in admixture more especially to form bottom grass. It is very appropriate in permanent mixtures on suitable soils. It is most valuable as a pasture grass at high altitudes.

XXI. Upright perennia brome.

Bromus erectus, Hudson.

Explanation of plate.

Fig. A. Entire plant in flower,
,, B. Basal portion of a culm shewing the extravaginal branches springing from it.
,, 1. Spikelet in flower.
,, 2. Spikelet before flowering.
,, 3. The pistil shewing the lateral styles.
,, 4. False fruit, ventral surface.
,, 5. False fruit, dorsal surface.
,, 6. False fruit, side-view.
,, 7. Caryopsis, ventral surface.
,, 8. Caryopsis, dorsal surface.
,, 9. Caryopsis, side-view.
,, 10. Transverse section of a young branch, shewing an entire sheath and three-folded leaf blades within.
,, 11. Transverse section of a blade of a culm-leaf.
,, 12. The ligule, short and obtuse.

Botanical description.

Botanical description. Upright brome is formed of a simple, compact tuft of branches. The *branches* are all extravaginal and ascend directly into the air without extending underground (fig. B.). The *culm* is rigid, erect, smooth and glabrous; its height varies from 1 to 3 feet.

The *leaf-sheath* (fig. 10) is entire and finely pubescent. The *leaf-blade* (fig. 10) is folded in the bud, a distinction from *Bromus inermis* which is convolute in the bud; its margins are fringed with long rigid scattered hairs. The blades of the radical leaves and barren shoots are usually permanently folded and narrow while, on the culms, they unfold, thus becoming flat and broader (fig. 11). In each blade, there are from 7 to 11 strong veins and between these from 6 to 10 weaker ones. The stronger are extended from the lower to the upper epidermis by the hard bast (fig. 11) and correspond to the shallow furrows which occur on both surfaces of the blade. The bulliform cells of the epidermis occupy the ridges; in most other grasses they correspond to the furrows as in the different species of *Festuca*. The *ligule* is short and obtuse (fig. 12).

The *panicle* is always upright (hence the name or the grass), narrow and contracted; its branches are short and rough; each branch bears very few spikelets. The *spikelet* itself (figs. 1 and 2) has a narrow lanceolate form and contains from five to seven flowers. The *lower pale* has from five to seven rough ribs and is awned, the awn being half the length of the pale. The *anthers* are saffron-coloured i. e. bright orange-yellow. The styles (fig. 3) are inserted laterally *beneath the apex* of the ovary (distinction from *Festuca).* The *ovary* is downy, especially at the apex (fig. 3).

The *false-fruit* (figs. 4 to 6) is slender, from 10 to 14 mm. long, not reckoning the awn, from 14 to 24 mm. with the awn. The *stalk* is very oblique at the apex, from 2 to 4.5 mm., long and covered with short rough hair. The lower *pale* is almost flat, with very slight curvature toward the ventral surface, hence almost the whole upper pale is seen when the false fruit is viewed ventrally (fig. 4). In this respect, the seed of upright brome very decidedly differs from that of various-leaved fescue: in the latter case, even the keels of the upper pale are concealed by the excessive ventral curvature of the lower pale. That portion of the upper pale which lies between the two keels is pressed down into the groove of the caryopsis. The longitudinal line which appears in the middle of this depression is the hilum seen through the pale (fig. 4).

The *caryopsis* (figs. 7 to 9) is dark brown, and boat-shaped (navicular); the ventral surface (fig. 7) has a broad shallow groove, the dorsal is slightly keeled (fig. 8). The apex bears traces of the pubescence of the ovary and the persistent remnants of the style on the sides near the apex. The black line occupying the middle of the ventral groove is the hilum.

Distinction from allied grasses.

Upright brome is liable to be confounded with meadow fescue. The brome can be distinguished at once by noting the lowest branches of the panicle, three or five of which originate from a common point of the axis, whereas in meadow fescue the lowest branches are either solitary or in pairs. The awns of the lower pales, and the long hairs fringing the leaves are also distinctive of the brome The resemblance to awnless brome grass (which see) is more marked. The latter has long underground stolons, whereas upright brome grows in tufts and never forms stolons.

Name.

The common names applied to this grass are: erect brome, upright brome, upright perennial brome, etc. In commerce, it is usually known as meadow brome *(Bromus pratensis,* Lamarck). It is also called upright fescue (*Festuca erecta,* Wallr.), mountain brome grass *(Bromus montanus,* Flora of Wetterau) and mountain fescue *(Festuca montana,* Savi).

History.

In Southern France, this grass has long been in cultivation, but only within recent years attempts have been made to grow it in more Northern lands. On some parts of the Cotteswold Hills it forms a large part of the pastures.

Agricultural value.

The fodder yielded by upright brome is only mediocre. Nevertheless, in certain circumstances it is very useful, especially on chalky or calcareous soils which are too poor or too shallow for sainfoin. Upright brome stands in the same relation to a chalky soil as sheep's fescue does to a poor sand. On poor chalk-land no other grass gives such satisfaction, whether used for cutting or pasture. It is not placed among the good fodder plants because of its high yield or nutritive value, but because it succeeds on certain poor soils where better grasses cannot be grown. In such circumstances, it is a veritable boon, but on good soils it is unprofitable and out of place. Grown under conditions suitable for it, it is a strong perennial. *Vilmorin* sowed it 20 years ago and still the grass is good, although manure has never been applied. Its duration depends much on the nature of the soil. In warm calcareous soils it lasts longer than in those which are deficient in lime.

Geographical distribution.

Occurrence, climate, soil, manure. Upright brome is indigenous: to *Europe* extending from Spain to the Urals and from Italy and Macedonia to Southern Scandinavia; in the North it is rarer; to *Africa* in Algiers; to *Asia* in Caucasus and Georgia. It is not indigenous to *North America.*

Habitat. In Germany, it is common on sunny exposures, on roadsides and fields, on dry sunny mountain pastures and especially prevalent on the calcareous soils of the Jura.

Limits of altitude. It does not occur at very high altitudes (Lowerz 1600 ft.) On the Bavarian Alps it ascends to 2400 ft. and at Talüsch to 7200 ft.

Climate. In favourable situations, upright brome is not inconvenienced by intense heat, but it cannot bear moisture. It is not sensitive to cold, but shade destroys it.

Soil. As noticed above, it succeeds best in calcareous soils. It also thrives quite well on soils which are dry, if they are somewhat stiff and calcareous. On loose sandy soils it is out of place.

Substances removed from the soil. 1000 lbs. of hay, cut on the 5th of June while in flower, from a dry exposed situation, contained:

Nitrogen	14.3 lbs.	Magnesia	1.9 lbs.
Phosphoric acid	6.8 ,,	Lime	4.4 ,,
Potash	16.8 ,,	Sulphuric acid	1.8 ,,
Soda	1.1 ,,	Silica	15.2 ,,

According to *Way* and *Ogston*, 1000 lbs. of hay contain:

Phosphoric acid	3.4 lbs.	Lime	4.6 lbs.
Potash	12.1 ,,	Sulphuric acid	2.4 ,,
Soda	0.3 ,,	Silica	17.2 ,,
Magnesia	2.2 lbs.		

According to *Demoor*, the amount of nitrogen is 5.8 per 1000. *Malaguti* and *Durocher* also analysed this grass; they do not state the proportion of ash, so that it is impossible to calculate the composition of the hay.

The composition of the ash is:

Phosphoric acid	9.98 %	Lime	8.32 %
Potash	13.25 %	Sulphuric acid	2.22 %
Soda	12.23 %	Silica	35.66 %
Magnesia	3.71 %	Oxide of Iron	3.99 %
Chlorine	10.13 %		

Manure. The remarks on the manuring of sheep's fescue also apply here. On soils which are poor in lime, marling is advantageous.

Growth. **Growth, yield, nutritive value.** Upright brome forms small, compact tufts. The culms (1 to 3 feet high) are not numerous. Both culms and leaves are somewhat hard. The tufts being compact cannot form a complete sward.

Development. If sown in spring the produce of culms for that year is small; full development is reached only in the second year. Growing as it does in situations exposed to sun, it shoots early in spring and comes into flower about the end of May or the beginning of June.

Harvest. It should, if possible, be cut before flowering, because soon after it becomes hard and withered, and the nutritive value diminishes. In the second cutting, there are usually no culms, only leaves. When used as a pasture grass, it should be treated like sheep's fescue. Leaves are produced in abundance and are readily eaten by stock.

Yield. According to *Sinclair*, 100 lbs. of grass, cut when in flower, gave 45 lbs. of hay; according to *Vianne* and *Demoor*, 42 lbs. At the time of flowering, *Sinclair* obtained 5819 lbs. of hay per acre from a rich sandy soil. *Demoor* obtained 7,480 lbs. and *Vianne*, from a well manured soil which was sandy, calcareous and poor, 7,080 lbs., the first cutting, and an aftermath about one-fourth as great.

Nutritive value.

100 lbs. of hay, cut while in flower, contain — organic matter 80.3 % composed of: —

Nitrogenous matter	8.9 %
(albuminoid - nitrogen = 1.032 %, non - albuminoid nitrogen = 0.385 %)	
Fat	2.2 %
Fibre	32.1 %
Non-nitrogenous extractives	37.1 %

According to *Way*, 100 lbs. of grass contain: organic matter 81.5 % composed of:

Albuminoids	8.1 %
Fat	2.8 %
Non-nitrogenous extractives and fibre	70.6 %

Demoor found only 3.6 % of albuminoids, but the hay he analysed was over-ripe. From these analyses, it is clear that the nutritive value is nearly equal to that of hay of medium quality.

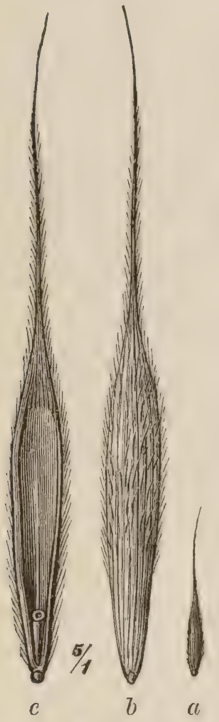

Fig. 47.
False brome grass.
Brachypodium pinnatum, P. B.
a. False fruit, natural size;
b. the same, dorsal surface × 5;
c. the same, ventral surface × 5.

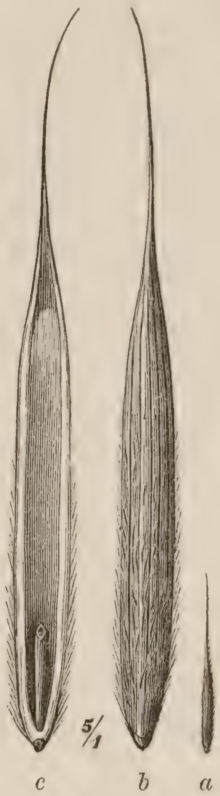

Fig. 48.
Rough brome grass.
Bromus asper, Murr.
a. False fruit, natural size;
b. the same, dorsal surface × 5;
c. the same, ventral surface × 5.

Harvesting the seed. Seed collection

Harvesting, impurities and adulteration of the seed. The seed is ripe about the beginning of July, and is easily harvested. The bulk of commercial seed is often nothing else than the cleanings from tall oat grass *(Avena elatior)*. These cleanings are very impure and are very frequently sold as the seed of upright brome. When such seed is sown, no brome appears for the first two years, although this grass was the main constituent of the mixture. The reason is clear. *Avena elatior* developes much more rapidly than the brome and, accordingly, forms the bulk of the produce. Only after the second year, when the tall oat grass is losing its vigour can upright brome gain the upper hand.

Impurities and adulterations.

The seeds of false brome, *Brachypodium pinnatum*, (fig. 47) are often labelled *Bromus erectus*. They are easily recognised by their straw colour and by the inner pale which is shorter than the outer, blunt at the apex, and comb-like on the margin. Rough brome, *Bromus asper* (fig. 48), a hard wood grass, is sometimes substituted. The seed of this brome is recognised by the abundant hair on the outer pale; upright brome has no hair there.

Seed quality.

Seed and amounts to be sown. The average purity is 80 % and the germination 64 % = 51.2 % of pure and germinating seed. On an average, one lb. of pure seed contains 114,000 seeds. A bushel weighs from 14½ to 15 lbs. 50 lbs. of seed are required per acre = 25½ lbs. of pure and germinating seed. The seed is sown either in spring or autumn.

Amount to be sown.

Mixtures.

It is not customary to sow upright brome alone. A little sainfoin or lucerne is mixed with it when the soil is suitable.

XXII. Awnless brome grass.

Bromus inermis, Leysser.

Explanation of plate.

Fig. A. Entire plant in flower.
,, 1. Spikelet before flowering.
,, 2. Lower pale, dorsal surface.
,, 3. False fruit, ventral surface (the two lines to the right indicate the maximum and minimum natural size).
,, 4. False fruit, dorsal surface,
,, 5, False fruit, side-view.
,, 6. Caryopsis, ventral surface (the two lines to the right indicate the maximum and minimum natural size).
,, 7. Caryopsis, dorsal surface.
,, 8. Caryopsis, side-view.
,, 9. Transverse section of a lateral shoot (two entire leaf-sheaths and two rolled blades).
,, 10. Transverse section of the blade of a culm leaf from the midrib to the margin.
,, 11. The ligule.

Botanical description.

Bromus inermis is entirely a stoloniferous grass. All its branches are extra-vaginal and form long, underground, root-bearing stolons (fig. A). The aerial portions of the branches thus stand separate from one another.

The smooth *culm* has a height of from one to four feet, and is abundantly provided with leaves. The *leaf-sheaths* are entire and glabrous (fig. 9). The *blade*, nearly three — fourths of an inch broad, has convolute vernation (fig. 9), and is usually spread out horizontally. On a transverse section (fig. 10) a projecting midrib is seen, and to the right and left six or seven weaker lateral ribs which, like the midrib, project on the lower surface. The bast portions of the bundles, constituting the larger veins, extend from the lower to the upper epidermis. Other veins, lying between these, are less strongly marked, and have little or no bast in connection with them. The upper surface of the blade shows shallow longitudinal furrows which correspond to the veins. The epidermis on the raised parts between the furrows is composed of »Bulliform cells« (fig. 10). The *ligule* is short, truncate, and finely toothed (fig. 11).

The *panicle* has widely spreading branches. The *spikelets* are large, slender and over an inch in length; the colour is reddish brown, with hight green strips (fig. 1). The *lower pales* are five-ribbed; towards the apex, the margins are broad, transparent, and membranous; the apex itself two-toothed and awnless (fig. 2), or, at times, a short awn may de developed. The *anthers* are orange yellow.

The *false fruit* (figs. 3 to 5) is quite flat, and from 10 to 13 mm. long. The lower pale is flat, except at the base, where it becomes curved round, so as to overlap the margins of the upper pale. The upper pale adheres so closely to the caryopsis that the hilum forms a projecting midrib on the pale (fig. 3). The stalk is short, covered with stiff bristles, and about one fourth the length of the false fruit. The caryopsis (figs. 6 to 8) is 6 to 10 mm. long, quite flat, acute at its ends, and covered with hair at the apex. It can only be separated from the adhering pale by boiling in water. Its ventral surface is then seen to be almost flat, with a shallow median furrow from which the hilum projects as a rib (fig. 6). From the dorsal surface it appears flat or slightly concave (fig. 7), from the side somewhat wary (fig. 8).

Name.

Awnless brome grass is sometimes spoken of as Hungarian brome or Hungarian fodder grass because it is extensively cultivated in Hungary. It is sometimes improperly called giant brome, but the true giant brome (*Bromus giganteus*, L., is quite another grass*). At times, it is called »couch brome« because it has the creeping, stoloniferous mode of growth of the common couch grass (*Triticum repens*).

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*) *Bromus giganteus*, L., grows usually in woods. It pales have very long awns. This grass has no agricultural importance.

History.

In 1769, *Nimrod* recommended it for binding river banks. He goes on to say: »This must be a good fodder grass, especially for sheep, because it grows in the cattle-rearing districts of Aschersleben, renowned for its exceedingly tender mutton«. Awnless brome grass has only quite recently come into cultivation, more particularly in Hungary.

Agricultural value.

Geographical distribution.

Although tall, this grass has only moderate value as a fodder plant. It soon becomes hard, its nutritive value is low and its creeping mode of growth makes it difficult to exterminate even when the land is broken up. In dry climates, and on dry loose soils, where better grasses do not grow, its strong perennial character makes it valuable. In Hungary, fields of it have been in use for 13 or 14 years and even longer, and still the yield is good.

Occurrence, climate, soil, manure. Awnless brome grass is indigenous to *Europe,* in France, Holland, Germany, Switzerland (very rare), Austria, Russia; to *Asia,* in Caucasus and Siberia.

Habitat

It is found wild on uncultivated heights, on the borders of roads, fields and forests, in hedges, by riversides, and more rarely in meadows.

Limits of altitude.

It does not grow at high altitudes (Bavaria 1,650 ft.).

Climate.

Thirty years' experience of this grass in Hungary shews that it withstands droughts so severe as to destroy all other fodder plants. It is not affected by cold. It cannot bear shade well. *Nimrod* states that plants grown in the shade bear awns.

Soil.

It thrives best on loose soils which are not too dry. The largest produce is obtained on soils rich in humus, on loamy sands and on sandy loams.

It can also be grown on soils of a stiffer type, but then better grasses can, with advantage, take its place. It is most valuable for covering sandy soils, bordering lakes and rivers. In such situations awnless brome finds sufficient moisture, although better grasses would not succeed. In Hungary, on soils incapable of producing lucerne, it is frequently used as a forage plant. It is less particular, with regard to the soil, than lucerne, and little preparation is needed.

Substances removed from the soil.

According to the Zurich experiments, 1000 lbs. of hay remove from the soil:

Nitrogen . .	7.7 lbs.	Magnesia . .	0.8 lbs.
Phosphoric Acid	8.3 ,,	Lime . .	3.4 ,,
Potash . .	16.3 ,,	Sulphuric Acid .	2.6 ,,
Soda . .	0.6 ,,	Silica . .	30.1 ,,

Manure.

This grass requires little manure. If the sand is too poor, manuring before sowing will further the development of the grass, more especially at first.

Growth.

Growth, yield, nutritive value. Like common couch grass *(Triticum repens),* awnless brome produces long underground stolons with numerous roots, which penetrate the ground in all directions. In the experimental field at Zurich, the underground parts, in spite of the stiff soil, extended into neighbouring fields. To extirpate it, the land had to be broken up. By this mode of growth, the ground is completely covered with grassy vegetation.

Development.

Numerous culms are produced. They are hard and leafy, and vary in height from one to four feet, according to the character of the soil. The leaves are broad, but thin and leathery. When sown in spring, a cutting can be obtained during the same year. In the second year, two crops can be taken. In spring it is later than other bromes, and only comes into flower about the middle of June. The aftermath shows no diminution in the number of culms, and the yield is almost as great as that of the first cutting. According to *Sinclair,* the produce diminishes after the second year; it is therefore advisable to break up the land, from time to time.

Harvesting and depasturing.

It can either be made into hay or used for grazing, although for the latter purpose, it is too hard to be very suitable. Cutting should begin if possible before flowering, because, at that stage, it becomes hard.

Depasturing should also commence early.

When allowed to become thoroughly ripe, the culms make splendid bedding, and can take the place of the straw.

Yield.

According to *Sinclair*, the produce per acre from a black siliceous sandy loam is:

1st cutting 6,125 lbs. of hay;
2nd cutting 8,848 lbs. of grass.

In Hungary, when the season is extremely dry, from 4,600 to 5,400 lbs. of hay per acre are obtained. At times, the yield is larger than that of lucerne. The Hungarians reckon, that an acre of pasture can carry 8 sheep for a summer. According to *Sinclair*, 100 lbs. of grass give 50 lbs. of hay.

Nutritive value.

According to the analyses made at Zurich, 100 lbs. of hay cut on the 30th June contain 78.3 % of organic matter, composed of:

Nitrogenous matter ($N \times 6.25$) (albuminoid nitrogen 0.52 %, non-albuminoid nitrogen 0.26 %)	4.9 %
Fat	1.6 %
Fibre	36.9 %
Non-nitrogenous extractives	34.9 %

The proportion of nutritive matter is thus seen to be considerably less than that of hay of medium quality.

Seed harvest.

Harvesting, impurities and adulteration of seed. After flowering, the panicle becomes contracted and assumes a brownish violet tint which ultimately changes to a straw colour. The spikelets are known to be ripe, when they have the violet tint which occurs about the middle of July. The culms are then cut and dried, and the seeds beaten out.

Yield of seed.

The yield of seed is considerable, and the grains themselves are large and heavy. The seed is flat and usually awnless (see under »false fruit« above).

Impurities and adulterations.

Impurities are rare. No attempts are made at adulteration. The seed of *Bromus asper* (fig. 49) might be confounded with this but they are immediately distinguished by their long awns. Under the name of giant brome, seeds of false brome *Brachipodium pinnatum* (fig. 50) and of rye brome *Bromus secalinus* (fig. 51) are at times offered for sale. The seed of the former have a long awn and a straw colour. The latter is a much heavier seed, rounder, stronger, and of a lighter colour.

Seed quality.

Seed and amounts to be sown. Good seed should have a purity of 90 % and a germination of 90 % = 81 % pure and germinating seed. One lb. of pure seed contains about 137,000 grains. 44 lbs. of seed should be sown per acre = 35.6 lbs of pure and germinating seed.

Sowing.

Awnless brome can be sown in spring or autumn. Spring-sowing with a summer cereal is usual. Autumn sowing with winter-wheat is also adopted, because the plant gives a full yield only in the second year. It is usual to grow it by itself because it easily suppresses other plants.

Mixtures.

At times it is mixed with lucerne (about 60 % brome to 40 % lucerne). Mixed with other grasses and clovers suitable for grazing purposes, it may form a constituent of permanent pasture mixture. Harrowing in spring is very beneficial.

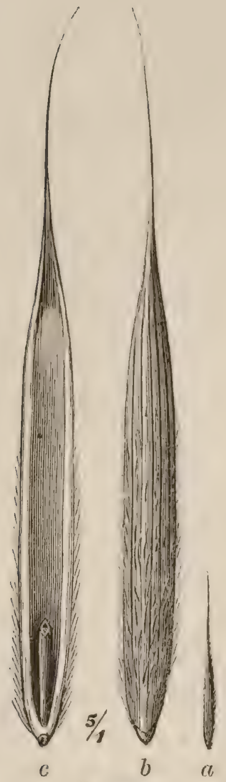

Fig. 49.
Rough brome.
Bromus asper, Murr.
a. False fruit, natural size.
b. The same, dorsal surface × 5.
c. The same, ventral surface × 5.

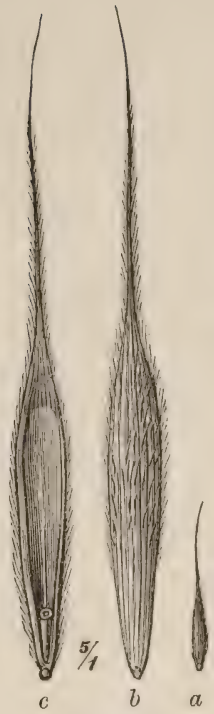

Fig. 50.
False brome.
Brachypodium pinnatum, P. B.
a. False fruit, natural size.
b. the same, dorsal surface × 5.
c. The same, ventral surface × 5.

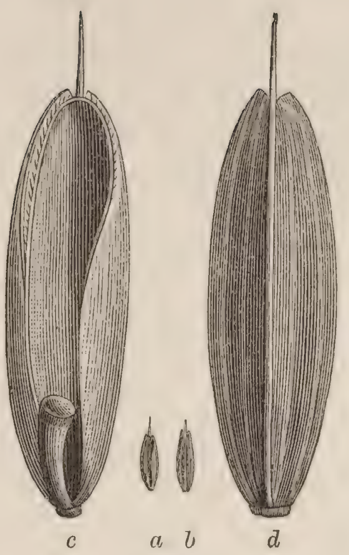

Fig. 51.
Rye brome.
Bromus secalinus, L.
False fruit.
a and *b.* Natural size.
c. Ventral surface × 8.
d. Dorsal surface × 8.

XXIII. Crested dogstail.

Cynosurus cristatus, L.

Explanation of plate.

Fig. A. Entire plant in flower.
,, B. The contracted inflorescence before flowering.
,, 1. The spikelet in flower.
,, 2. The spikelet after flowering.
,, 3. The pales from the side.
,, 4. The pales ventral surface, shewing the upper pale.
,, 5. The pales dorsal surface, shewing the lower pale.
,, 6. The upper pale, lodicules and ovary.
,, 7. The barren spikelet.
,, 8. False fruit, the short, stout variety } from the ventral surface.
,, 9. False fruit, the long, slender variety } from the ventral surface.

Fig. 10. False fruit, the short, stout variety } from the dorsal surface.
„ 11. False fruit, the long, slender variety }
„ 12. False fruit, the long, slender variety } from the side.
„ 13. False fruit, the short, stout variety }
„ 14. The caryopsis, ventral surface.
„ 15. The caryopsis, dorsal surface.
„ 16. The caryopsis, side-view.
„ 17. Transverse section of a lateral shoot, shewing a split sheath, two entire sheaths and two leaf-blades.
„ 18. Transverse section of a culm leaf.
„ 19. The ligule of a culm leaf.

Botanical description.

Crested dogstail forms a loose tuft of grass composed of intravaginal branches. The *culm* is ascending, bent at the base and at times rooting from the basal nodes, smooth and rigid, from one to two feet in height.

The whole *leaf-sheath* is entire except near the very apex where it is split.

The *leaf-blade* when in bud is folded at first; later the margins merely overlap; both stages are shewn in fig. 17. When fully developed, the blade opens out; the upper surface always retains a slight concavity und has well marked ribs. The transverse section (fig. 18) shews the midrib and ten ribs on each side of it, twenty one in all. On the lower surface, the ribs are quite indistinct. To each rib corresponds a vein (vascular bundle) and two bundles of bast, one above and one below the vascular bundle. With rare exceptions, the bast bundles are always isolated from the vascular bundles. The *ligule* is short and obtuse (fig. 19).

The *inflorescence* is a contracted spike-like panicle, its length varies from two to four inches. At first (fig. B) the parts, which compose it, are quite compact, and the whole is cylindrical. Later (fig. A) the axis lengthens, the parts spread out and become less compact, and the whole inflorescence has assumed a somewhat conical form. The axis is triangular and zigzag.

The spikelets are attached in such a way as to leave one side of the axis quite bare, a very characteristic feature. Sometimes the axis becomes twisted; then, of course, the unilateral character is lost. The spikelets never occur singly; two or more are always found together attached to a common stalk which is very short. These short stalks are fixed upon the axis of inflorescence.

The *spikelets* are of two kind, fertile and barren. The *barren spikelet* (fig. 7) is like a comb with two rows of teeth. It is composed of an axis bearing as many as ten pales. These pales are narrow, strongly keeled and ciliated, and produce no flowers in their axils i. e. they are empty. Each barren spikelet is placed externally to a fertile one, so as to form an involucre for it — the comb-like (pectinate) involucre of authors. On the young inflorescence in fact, the barren spikelets cover up all the others, and as they are alone visible, the crested appearance of the grass is very marked.

The *fertile spikelet* (figs. 1 to 6) is composed of three (figs. 1 and 2) or four flowers and a pair of glumes. The *glumes* are narrow, almost as long as the whole spikelet, and ciliated on the keel. The *lower pale* has either no awn or only a very short one, and five indistinct ribs; the back is rounded and toward the apex, has stiff, bristly hairs (figs. 1, 2, 3 and 5). The *upper pale* has two keels very close together, and broad margins curved inwards; the apex is obliquely truncate (figs. 1, 3, 4 and 6).

There are two *lodicules,* half as long as the ovary and overlapping the margins of the upper pale (fig. 6).

The *false fruit* (figs. 8 to 13) varies much in size; it is either short and stout, three mm. long and one mm. broad (figs. 8, 10 to 13), or long and slender $4^{1}/_{2}$ mm. long and $^{1}/_{2}$ mm. broad (figs. 9, 11 and 12); all transitions between these extremes occur. The *lower pale* is always light brown in colour, covered towards the apex with rough bristles and finely dotted towards the base. The *upper pale* is dark brown in colour and covered with dark shining dots (probably resin-glands?). The *stalk* is very short.

The *caryopsis* is at most two mm. long and somewhat flat; the ventral surface is scarcely grooved; the dorsal shews the small embryo at the base (figs. 14 to 16).

Name.

This grass is usually spoken of simply as dogstail, because other species of the genus are rare and of no agricultural importance. The name dogstail refers to the form of the inflorescence. At Hamburg it is called »Kammsaat«, at Berne »Herdgras« and at Darmstadt »Goldspitze« from the colour of the seed.

History.

To England is due the credit of first introducing this grass to the notice of agriculturists. *Stillingfleet* grew it along with Timothy as early as 1761. It had the reputed property of preventing foot rot in sheep pastured upon it.

Agricultural value.

Crested dogstail has high nutritive value, and when grown in mixture with taller plants, adds considerably to the produce of bottom grass. Its high nutritive value, leaving the amount of produce out of account, suffices to give it a place among the best fodder grasses. Along with perennial rye-grass, smooth-stalked meadow grass and red clover, dogstail abounds in the excellent pastures at Berkeley in England. To the presence of these grasses, the renown of the pastures as well as of the cheese produced in that district has been attributed. At any rate, the most renowned pastures of England, Holland and Schleswig-Holstein contain abundance of crested dogstail. In the pastures of the Alps also, it is one of the most abundant grasses. It is perennial and is used to form bottom grass either in hay or in pastures.

Geographical distribution.

Occurrence, climate, soil, manure. Dogstail is indigenous to the whole of *Europe* from Portugal to the Urals, extending from Greece and Italy in the south to Sweden and Finland in the north; to *Asia*, in Caucasus and Georgia. It is not indigenous to *America*.

Habitat.

On good soils, it is common everywhere in meadows and on hills, by road sides and the borders of fields, and in grass-land whether moist or dry.

Limits of altitude.

On the Alps it ascends to high altitudes (Klosters 3,900 ft., Rellsthal 3,900 ft., Gurnigel 4,200 ft., Napf 4,600 ft., Seelibühl 5,700 ft.). In Switzerland it is more abundant on the lower Alps than on the plains.

Climate.

Moist climates are most suitable for dogstail; and on mountainous and in maritime districts it is therefore very successful. It withstands drought very well, as its root-system descends to a considerable depth into the ground. It also thrives well in shade.

Soil.

It succeeds on almost all kinds of soil, especially on those of a medium type which are rich in humus, *e. g.* loams, mild clays, marls and loamy sands. On stiff clays it also grows well. On sour soils or loose sands it does not thrive. It loves moist land, but is also found on dry and even on sandy soils; in the latter case, its growth is more or less stunted. On moist soils it developes well; very wet land is not suitable for it and it is out of place there.

Substances removed from the soil.

According to *Way and Ogston*, 1000 lbs. of hay cut when in flower remove from the soil: —

Phosphoric Acid	4.0 lbs.	Lime . .	5.6 lbs.
Potash . .	17.7 ,,	Sulphuric Acid .	1.8 ,,
Magnesia . .	1.3 ,,	Silica . .	22.0 ,,

According to *Arendt*, the following amounts are removed: —

Nitrogen . . .	22.8 lbs.	Lime	3.2 lbs.
Phosphoric Acid .	5.4 ,,	Silica	29.7 ,,
Magnesia . . .	1.3 ,,		

According to *Way* the percentage of Nitrogen is 1.52, according to *Ritthausen & Scheven*, only 1.05.

Manure.

To grow dogstail successfully, the soil must be somewhat rich. Manures of all kinds are beneficial especially those containing nitrogen. Liquid manure and irrigation have a very beneficial action. The largest yield is obtained on irrigated and well drained land.

Growth.

Growth, yield, nutritive value. Dogstail forms small, simple tufts; at times, some of the branches may creep along the ground for a short distance. When sown sufficiently thick, it forms a complete sward. The culms are not very numerous; the height varies from one to two feet. The radical leaves are produced in abundance. They vary much in breadth, according to the nature of the soil. Few culm leaves are produced and they soon become hard.

Development.

The full yield is obtained during the second and third years after sowing. This grass occupies a middle place between the late and early grasses, as it comes into flower about the end of May or the middle of June. The aftermath is, however, largely increased by its leafy shoots and culms which have meanwhile been produced. The leaves begin to develop as early as those of other grasses, but the culms are later in making their appearance.

Depasturing.

Depasturing should begin early. It is better to depasture early because the culms begin to harden, almost as soon as they appear and are liable to be left standing.

In summer, alpine pastures are often quite thickly covered with the culms of dogstail left in this way. It is an error to conclude from this that cattle do not like the grass, as the leafy shoots are quite readily eaten. In a pasture, it is impossible to keep the grass so closely cropped that the culms are prevented from forming. If other tufted grasses abound in mountain pastures, their culms will usually be left standing like those of dogstail: this character, then, ought not to be regarded as peculiar to any one grass. For example, in districts where red fescue enters largely into the composition of the pasturage, abundance of its culms are found standing during summer. The same remark applies to perennial rye-grass in the marshy districts of England.

Yield.

Vianne obtained from a fertile soil 2700 lbs. of hay per acre. *Sinclair* obtained from an acre of manured loam 1838 lbs. of hay in the first cutting and 3403 lbs. of green aftermath. According to *Sinclair & Vianne* 100 lbs. of grass give 34 lbs. of hay. According to *Ritthausen & Scheven* only 31 lbs.

Nutritive value.

Chemical analysis shews that the nutritive value of this grass is high: 100 lbs. of hay contain: —

	Way.	Ritthausen & Scheven.	Arendt.
Organic matter	80.4 %	78.8 %	78.9 %
composed of: —			
Nitrogenous matter . . .	9.5 %	6.6 %	14.3 %
Fat	3.1 %	2.2 %	3.5 %
Fibre	22.6 %	36.7 %	
Non-nitrogenous extractives . .	45.2 %	33.3 %	

The small amount of nitrogenous matter and fat in the second analysis probably depends on the circumstance that the plants were taken from a very moist soil. According to the other two analyses, dogstail is superior in nutritive value to hay of medium quality.

Harvesting of seed.

Harvesting, impurities and adulteration of seed. By the end of July or the beginning of August the plants are ripe. At the proper stage of ripeness the seed can readily be rubbed out, the pales are yellow, and the caryopsis has a leathery consistence.

If cut too early, the seed obtained germinates badly, and if too late, many seeds are lost. Plants for seed are cut in the same way as those of perennial rye-grass. After drying they are allowed to ripen in the barn. Threshing is easy. At the present time it is not customary to grow the grass specially for seed; wild plants are used for the purpose. As a consequence, the supply is hardly equal to the demand and the price has risen. Greater attention must now be paid to seed production. On the Swiss Alps where dogstail is exceedingly abundant, seed could profitably be collected without injury to the pastures.

Yield.

Hannemann & Werner estimate that an acre grown for seed yields 180 lbs.

Impurities and Adulterations.

This seed is often mixed with that of Yorkshire fog *(Holcus lanatus)*; doubtless this addition is intentional. *Holcus* seeds are bright, shining, white in colour and rounded at the apex, while those of dogstail are acute, awned and provided with short bristly hairs toward the apex (fig. 52). Adulteration with capillary sheep's fescue, *Festuca ovina capillata*, Hackel (fig. 53) is more difficult to detect. The seed of this adulterant is usually shorter and less acute than that of dogstail; it is almost smooth and has a reddish straw colour. The seeds of purple melic, *Molinia cœrulea,* Mœnch (fig. 54) are sometimes intentionally added. They are smooth, less acute, of a reddish straw colour and swollen at the base; the pales usually gape at the apex. The swollen base and gaping pales are very characteristic.

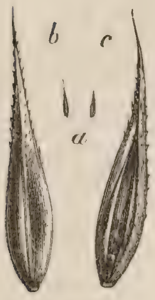

Fig. 52.
Crested dogstail.
Cynosurus cristatus, L.
a. False fruit, natural size.
b. the same, ventral surface × 7.
c. the same, dorsal surface × 7 (after Nobbe).

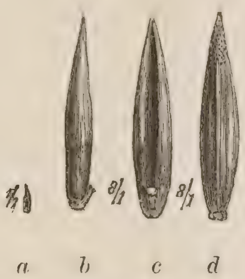

Fig. 53.
Capillary sheep's fescue.
Festuca ovina capillata, Hackel.
a. False fruit, natural size.
b. The same, side-view × 8.
c. Ventral surface × 8.
d. Dorsal surface × 8.

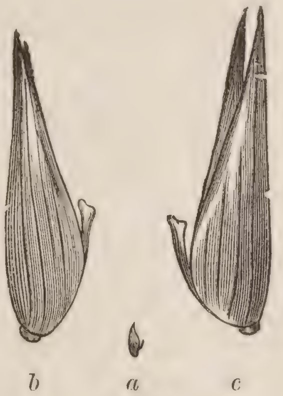

Fig. 54.
Purple melic.
Molinia cœrulea, Mœnch.
False fruit, side-view.
a. Natural size.
b. and *c.* × 8.

Seed quality.

Seed and amounts to be sown. Good seed ought to have at least 90 % purity and 60 % germination = 54 % of pure and germinating seed. One lb. of pure seed contains, on an average, 1,127,000 seeds.

Amount to be sown.

The weight per bushel varies between 20 and 32 lbs., that is, on an average, 26 or 27 lbs. 25 lbs. are required per acre; that is 13.5 lbs. of pure and germinating seed.

Mixtures.

Dogstail is only sown by itself for the purpose of obtaining pure seed and, at times, for forming permanent lawns. It is very well adapted for the latter purpose since it forms a low and complete sward of compact grass when thickly sown. In mixtures it is used to form bottom grass either in pasture or hay. It is very suitable for permanent grassland. It can also be used in alternate husbandry for leys of 4 or 6 years. In a pasture it is self-multiplying; its seeds reach maturity, fall off and form new plants.

XXIV. Red clover.

Trifolium pratense, L.

Explanation of plate.

Fig. A. Part of a plant in flower.
„ 1. Complete flower, side-view.
„ 2. Longitudinal section of a flower.
„ 3. Flower seen from the longer surface.
„ 4. Flower after removal of the standard, seen from the upper surface.
„ 5. The wing showing the claw and appendage.
„ 6. The pistil.
„ 7. The fruit.
„ 8. Broad side of the seed.
„ 9. Edge of the seed, showing the hilum.

Red clover is biennial or perennial. The *primary stem* always remains quite short and bears a rosette of radical leaves, but never flowers.

The *secondary branches* spring from the axils of the radical leaves; they are ascending from 12 to 20 inches high, and either glabrous or pubescent with compressed down. Each of those branches bears leaves (cauline) along its sides, and at the apex is a flower-head. *Tertiary branches* also, terminated by flower-heads, are often formed.

The *leaves* are compound and ternate. The radical leaves have longer petioles than the others.

The uppermost pair of leaves on a branch is placed immediately beneath the terminal head of flowers, so as to form a kind of involucre. The flower-head of *Trifolium sativum* (see under varieties) is separated from the uppermost leaf-pair by a short stalk. The *leaflets* are ovate, the margin is almost entire and bordered by fine hairs. The *stipules* are membranous, traversed by green veins and adnate to the petiole; the free apex is triangular and sharply prolonged into an awn-like process.

The *flower-head* (capitulum) is spherical or ovate, usually solitary, sometimes paired; immediately beneath is placed the pair of modified foliage-leaves already referred to as forming a kind of involucre.

The *calyx* (figs. 1, 3, 4) is sparsely hairy, and greyish green; the tube is ten-ribbed; from its apex spring five filiform teeth, the inferior (fig. 3) twice as long as the others. The *corolla* is reddish purple, rarely white: its basal portion unites with the base of the nine lower stamens to form a tube 9 to 10 mm. long. The free portion of the standard (figs. 1 to 3) is very broad and springs from the upper lateral part of the tube. Its base overlaps all the other petals (fig. 3). The free portion of the keel (figs. 1 to 4) is a deep spoon-like structure (fig. 4), which contains the stamens; it is a prolongation of the lower portion of the tube. The wings (figs. 1 to 5) are attached to the tube by a slender claw (fig. 5); beyond the claw, each wing becomes broad and sends out a process (fig. 5) which is directed backwards and over the keel, so as to grip it firmly (figs. 2 and 4). The nine cohering *stamens,* remain united as a stamen-tube for a short distance after they become free from the corolla.

The stamen-tube soon breaks up into nine free filaments which are bent upwards so as to lie in the keel. The single free stamen (fig. 2) is uppermost and runs along the inner face of the corolla-tube. Ultimately, like the other nine stamens it bends so as to lie within the keel.

The *pistil* is attached to the base (*thalamus*) of the flower and is surrounded by the common tube formed by the union of the corolla and stamens (fig. 2). The ovary is short and usually contains two ovules (figs. and 6). The *style* is long, filiform and curved. The *stigma* (figs. 2 and 6) is contained in the cavity of the keel beyond the anthers (fig. 2).

Red clover is one of those plants which remain barren and cannot produce seed, unless visited and fertilized by insects. It is absolutely necessary that the pollen be conveyed to the stigma by insect guests. *Darwin* found that 100 heads of red clover produced no seed when covered by a net to prevent the visits of insects to the flowers. Another 100 heads growing by the side of the former to which insects had access produced about 2720 seeds. The observations of *Darwin* and *Müller* shew that bees are the chief fertilisers of red clover. *Müller*, for example, found that 19 species of bee and 26 other species, belonging to the orders *Hymenoptera* and *Lepidoptera*, visited and fertilized the flowers. The insects come to obtain honey and pollen. During the visit some of the pollen which has attached itself to the body of the insect, becomes fixed upon the stigma, and thus fertilization is secured. The pollen which is effective, has in all probability been taken from some other flower, previously visited. *Cross-fertilization* is thus accomplished. There is, however, no experimental evidence to show that pollen from a flower cannot, when applied to its own stigma, fertilize it.

The flower is specially adapted for fertilisation. The nectar which the insects seek is secreted at the base of the tube formed by the united corolla and stamens; it collects round the base of the ovary. There is an open passage to the honey beneath the standard and between the wings. The insect takes up its position on the flower, inserts its proboscis and extends it in order to reach the base of the tube and sip the honey. To reach the honey the proboscis must be nine or ten mm. long — the same length as the tube of the flower. When the insect is sipping the nectar, it is standing on the wings and keel. The weight of its body presses down these organs and the stigma and stamens come into contact with the under surface of the insect's head. The stigma is now fertilized by pollen from the insect and at the same time pollen is removed from the flower and attached to the hairs on the insect's body. When the weight is removed by the flight of the insect, the elasticity of the keel brings the parts back to their original position, and the sexual organs are again enclosed in the keel. The processes which lock the wings to the keel aid in bringing the parts back.

Some insects bore a hole in the corolla immediately above the calyx, and in this way, even though their probosces be short (7 to 9 mm.), they can readily reach the honey, without effecting any fertilization. The hole made by such robbers may again be used by other insects visiting the flowers later on.

The *fruit* (fig. 7) is a one-seeded pod, divided by a transverse joint into two chambers, an upper and a lower. The upper is a smooth, shining, thin-walled cap; the lower a small, thin-walled box, which readily tears and allows the seed to escape. The pod of clover does not open by two valves and in this respect it differs from the legume generally characteristic of leguminous plants.

The *seed* (figs. 8 and 9) itself is suborbicular or oblong and somewhat flat. On one of its edges, the radicle of the embryo forms a distinct projection, near the apex of which is the hilum (fig. 9). The colour is reddish or mustard-yellow, sometimes yellow on the edges and red on the surfaces.

Because of its wide and extensive cultivation, this clover has received very varied local names. In this country it is usually called red clover or cow-grass. Name.

Red clover has contributed even more to the progress of agriculture than the potato itself, and has had no inconsiderable influence on European civilisation. Its cultivation has led to an increased production of stock as food for man, and in this way has fostered and advanced commerce, industry and science. Although indigenous to Europe, red clover has only been introduced to cultivation within comparatively recent times. History.

The ancients did not cultivate it, although the plant itself was certainly known in Europe and the temperate regions of Western Asia. It was first cultivated in Media, but at what date is uncertain. During the fifteenth and sixteenth centuries it was introduced into Spain and Italy. In 1550, *Gallo* mentions it as occuring in Italy; in 1556, its cultivation was recommended to the senate of Venice by *Tarelli*. From Spain, its cultivation spread during the sixteenth century to Brabant and Flanders. Emigrants from these countries introduced it into other lands. About the beginning of the seventeenth century Germany was plunged into the 30 years' war which put a stop to agriculture there for a long time. Thus it happened that the cultivation of red clover made no considerable advance in Germany, till the beginning of the eigteenth century. In the Palatinate *Casimer Medicus* brought it into notice between 1760 and 1770. Into Switzerland it was introduced by *Tschiffeli* who founded the agricultural society of Berne in 1759. Before this time it had been cultivated here and there in Switzerland under the name of Holland or Spanish clover, as the seed had been obtained from these countries, but, thanks to the efforts of the agricultural society of Berne, its cultivation soon extended throughout the whole country. In Germany, as in Switzerland, it was necessary to change the prevailing system of rotation in order to introduce the clover. A three years' rotation was in vogue: 1. wheat, 2. barley, 3. bare fallow. *Schubart* recognised the necessity of making a change in the system, and introduced clover and root-crops instead of the bare fallow. This improved system soon became general. Red clover was introduced into England from Flanders about the year 1633, and especially owing to the efforts of Lord Chancellor Weston, Duke of Portland, its cultivation soon spread. It was introduced into North America between 1790 and 1800.

Varieties.

In agriculture, two principal varieties are distinguished: 1. Wild clover or cow-grass, *Trifolium pratense* L., var. *pratorum*, Alefeld = *Trifolium pratense* var. *perenne* Host. 2. Cultivated red clover *Trifolium pratense* var. *sativum*, Schreber & Hoppe.

The first variety is distinguished from the second by the following characters: the height is less, the root is much branched and very fibrous, the stem is usually more hairy and full of pith (not hollow), the radical leaves have rounded leaflets, one and a half times longer than broad, the involucral leaves are sessile and very close to the capitulum; the free portion of the stipule is longer, narrower and provided with longer hairs; the capitula have fewer flowers, but appear to be as large as those of the other variety *(Sinclair)*, and the pedicels of the flowers are usually longer, thinner and bent. It is not possible always to distinguish the one variety from the other. Cow-grass has the following points of advantage over the other variety: — it lasts longer (for two or three years); it is less sensitive to soil and climate, and as a consequence, the crop is more certain; and hay-making is easier. Genuine seed is, however, more difficult to obtain and is dearer.

Cultivated red clover, the second variety, is also called Spanish, Welsh, Brabant, etc. clover. It is a larger plant than the other, and can only be used for a single year. The characters which distinguish this from the first variety are: — the tap root branches little and produces few fibres; the stem is longer and usually hollow, the capitula are often in pairs, and separated by a stalk from the uppermost sessile involucral leaves; and the flowers are usually lighter in colour. This variety has been produced by cultivation, as is easily proved experimentally.

If genuine seed is collected from wild cow-grass, and sown for several generations, plants are obtained which cannot be distinguished from the variety *sativum*. Also when both varieties are cultivated together for a few years, the plants become similar in their mode of growth and properties and of equal value.

In selecting seed for use, the country which grew it should be carefully noted, as red clovers from different countries have characteristic properties. 1. *Red clover from Switzerland* has been in cultivation there for a long time; it is a hardy plant of luxuriant growth. 2. *Red clover from Styria and Silesia* is taller and flowers later than the Swiss; it is more lasting and hardier than the following kinds. 3. *Red clover from France* does not attain the height of the preceding, is less lasting and less hardy. 4. *Red clover from Alsace and the Palatinate* ranks between the French and Silesian varieties.

5. *Italian red*, although very early, soon disappears; it is so sensitive to cold that the crop is often destroyed during the first winter. 6. *English red* is tall, produces abundance of sap and leaf, and is lasting; it ought to be regarded as the best clover in northern Europe. 7. *American red* has in recent times been largely imported into Europe. Opinions regarding it are divided; it ought, therefore, to be used with caution. It is provided with abundance of hairs, an arrangement for diminishing the amount of transpired water. As far as produce is concerned it almost equals *European reds*, but it is less hardy and more liable to be affected by variations of temperature and mixture than other varieties. At Copenhagen, *Lund* has tried it experimentally*). After the rigorous winter of 1878—79, he found on a square foot of ground 17.1 plants of European red and only 5.4 plants of American red.

American red was thus proved to be three times less resistent to extreme winters than European red. In less severe winters, American is equal to European red. It is clear that great risk is run when American seed is used. It is probable that, at times, the clover-sickness of the land, as it is called, may be due to the use of American seed which is not yet thoroughly acclimatised here; this is the more likely as, in commerce, American seed is often substituted for European. The produce from American seed is also less. *Nielsen*, of Oerslev, obtained from a good soil as the average of fourteen trials the following results: —

	Hay per acre:
From European seed . .	9,200 lbs.
„ American „ . .	8,400 „

On an inferior soil the following was the result:

	Hay per acre:
From European seed . .	7,170 lbs.
„ American „ . .	6,400 „

The average weight of a single plant of European red was 103 grains, that of the American $67^{3}/_{4}$ grains.

Trifolium pratense alpinum Hoppe, or *Trifolium pratense nivale*, Sieb., is the variety found on the Alps. It has very low stature, large capitula and dirty white flowers.

Agricultural value.

Schwerz has well remarked that red clover is more valuable among fodder plants than wheat is among cereals. The opinion of this celebrated agriculturist is quite correct. But in recent times the cultivation of other clovers and grasses has made immense progress, so that rational mixtures of grasses and clovers can now be produced which will, as a general rule, give a better result than a pure sowing of red clover. In these clover grass mixtures, red clover usually forms the chief constituent. For stall feeding in summer, red clover by itself is certainly better that any other fodder. But the crop is not always certain, and to ensure success, great attention and skill are necessary. The land must be well tilled, well manured, and for a number of years, have borne no clover. Red clover can be introduced into any rotation. Usually it is sown with a cereal in spring, and used the following year. In autumn a pure sowing of red clover is ploughed up, for, although the wild plant is perennial, utilisation for a longer period is uncertain. In practice, this clover must be regarded as of two years' duration. During the third year, many of the plants die, the crop becomes thin, and the produce is greatly diminished.

Geographical distribution.

Occurrence, climate, soil, manure. Red clover is indigenous throughout *Europe*, except Greece; also in Algeria, Anatolia, Armenia, Turkestan, Siberia (Ural, Altai, Baikal), India, Cashmere and Garwall. It is now naturalised in *North America*.

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*) Om Landbrugets kulturplanter og dertil horende Froavl. Nr. 2. Copenhagen, 1881.

It occurs wild in good meadows. The abundance of the clover may be regarded as a rough indication of the fertility of the land. It also grows on roadsides, the borders of fields, grassy spots in woods and in pastures.

Limits of altitude.

On the Alps and Pyrennees, the alpine variety ascends to a height of 8200 feet and in Southern Spain to 9800 ft. On the mountainous districts of southern and central Germany, cultivation is carried on at altitudes exceeding 3300 ft.

Climate.

In spring, red clover is very sensitive to dry cold. It loves moisture and heat in April, May and June. It can be grown with advantage in all wheat producing regions, as well as in a lower zone than spring wheats. During snowless winters many plants are uprooted by the alternate freezing and thawing of the ground and perish from this cause. This effect is most pronounced on soils which are loose, shallow and rich in humus. In such cases, thorough rolling is advantageous and counteracts the effect of the frost.

Soil.

So far as mere soil is concerned, red clover is not so particular as lucerne or sainfoin. Its root-system does not descend so deep and, therefore, the nature of the subsoil is of less importance. It thrives best on marls which are rich in humus, as well as on damp, fertile loams and clays containing a little lime. As a rule it thrives better in heavy than in light soils. The stiffest clays, when properly tilled, can grow it, but, in no case, should stagnant water be present. A loamy sand, sufficiently moist and rich in humus, is appropriate for clover growing. Dry sands, hot calcareous soils, as well as moorland and marshy grounds are unfavourable. By stiffening the former with clay and liming or marling the latter, such soils may be rendered capable of carrying clover.

On loose, spongy soils and on mountain slopes, watered by springs, it is liable to be destroyed in winter, being uprooted by alternate freezing and thawing; on sands and on fields too much exposed to sun, it suffers from drought; and on poor land it becomes stunted and thin.

If the subsoil is ferruginous or ochreous, it will not grow; if rocky and impervious to water and the soil thin, not a plant is produced.

To satisfy its requirements, the soil must be stiff, humid, rich and contain some marl or lime: the soil must be neither wet, nor sandy and liable to drought, nor thin, nor ochreous, nor impoverished by the preceding crop.

Substances removed from the soil.

1000 lbs. of red clover remove from the soil: —

Nitrogen	19.7 lbs.	Lime	20.0 lbs.
Phosphoric acid .	5.6 ,,	Magnesia . . .	6.1 ,,
Potash	18.3 ,,	Sulphuric acid . .	1.7 ,,
Soda	1.2 ,,	Silica	1.4 ,,

Manure.

Red clover succeeds only in good fertile soil. During growth, no manure except gypsum is ordinarily applied.

Gypsum is sulphate of lime, or calcium sulphate, and when pure is composed of:

Sulphuric acid . .	46.51 %
Lime . . .	32.56 %
Water . . .	20.93 %

Gypsum is commonly used as it comes from the quarry i. e. unburnt. It is pulverised and scattered on the clover about the end of April or the beginning of May, at a time when the weather is moist and warm. From 3 to 5 cwt. per acre may be used. The effect of gypsum depends upon the nature of the soil, the weather and the climate. On a poor soil there, is no effect because gypsum acts indirectly as a manure and serves merely as a whip to make the dormant matter active, thus placing nutritive matter at the disposal of the plant. Where there is no dormant matter in the soil there can be no beneficial action. The effect is most marked on fertile soils, in moist, warm weather on as there is then sufficient water to dissolve the gypsum. One part of gypsum requires 400 parts of water to dissolve it, clearly there can be little or no action in dry ground. Mayer commenced experiments with it in the Palatinate as early as 1765. Since his time numerous experiments have been made to determine its action, but these may be passed over.

At times, an application of wood-ashes gives good results. *Schwerz* relates that the village of Kriegsfeld in the Palatinate, which had been devastated in the war and almost abandoned by its inhabitants, was restored to prosperity through an excellent crop of clover, produced by means of an application of the ashes left from burning the village. Chili saltpetre has very rarely been successfully used as a top-dressing. Sulphate ammonia also rarely gives remunerative returns. In fact red clover seldom responds to any application of nitrogenous manure; it obtains the large amount of nitrogen it requires from other sources than those available to the grasses, probably from the subsoil, possibly from the air.

At the end of autumn a covering of undecomposed farmyard manure prevents the uprooting of the plants by alternate freezing and thawing.

This clover ought not to be cultivated on irrigated land. Meadows intended for irrigation usually receive no water for the first two years, then of course red clover can be grown, but after irrigation the land is unsuitable.

Growth, yield, nutritive value. The first leaf produced by red clover is not ternate like the succeeding leaves, but simple and rounded. At first the tap-root penetrates the soil with comparative rapidity while the parts above ground grow much more slowly. In the axils of the radical leaves buds soon make their appearance. The lowest grow out and become secondary branches; these in turn may again branch. If sown in spring with a cereal, by midsummer the branches in the air and the roots in the ground are almost equally developed. Growth.

The tap-root penetrates deep into the ground and produces numerous lateral roots which again branch abundantly. These lateral roots penetrate the ground in all directions and extract mineral matter and water from it. Peculiar wartlike growths containing albumin and bacteria develope on the rootlets; the physiological meaning of these growths is not year clear. Similar warts occur on must leguminous plants. After a time, the roots begin to shorten and the basal parts of the plant and radical leaves are pulled downward into the ground. This change protects the lower buds from the scythe, gives the plant a firmer hold of the ground, and prevents uprooting during winter. Similar root-contraction is very conspicuous in carrots. In summer the carrot-top is above ground, in autumn below. The experiments of *Hugo de Vries**) shew that a tap-root of red-clover, 2 mm. thick, became 10% shorter in six weeks, by root-contraction. After cutting, the whole stem dies down, except the short, bud-bearing internodes at the base; these buds soon develope and become new branches. When clover is cut for seed, the whole stem usually dies and becomes rotten and hollow. For this reason there is little produce after a seed-crop has been taken.

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*) *H. de Vries*, Wachsthumsgeschichte des rothen Klees. Landwirthschaftliche Jahrbücher von Nathusius & Thiel. Bd. VI. Berlin, 1877.

Development.

If the season be favourable, red-clover sown in a cereal crop developes sufficiently by autumn of the same year to be used either for pasturage or cropping; of course, only a small crop can be taken. Stubble clover, as this crop is called, ought to be cut early enough to allow some development of the buds to take place before they are surprised by frost. The shoots produced by the development of these autumn buds have always two surfaces and two edges, and, during winter, lie quite flat on the ground. The plant, in fact, brings itself as close as possible to the ground to protect itself against the frost which acts most injuriously when severe, or when followed by sudden thaw. In spring, the young shoots and leaves again begin to grow and form new shoots.

Flowering takes place about the end of May or the beginning of June.

Harvesting.

When used green, cutting ought to commence some time before flowering; if left later, the stem becomes hard and woody. In its youth red clover is richest in albuminoids and contains least woody-fibre as shewn by *Ritthausen's* analyses.

Red clover hay containing 16.7 % of water is composed of:

	Quite young.	13th June.	23rd June.	20th July.
Albuminoids	21.9 %	13.8 %	11.2 %	9.5 %
Woody-fibre	24.7 %	32.8 %	32.9 %	48.7 %

It is clear that as the plant grows older, the more useful constituents gradually diminish while the less valuable increase.

Further, the nutritive matter contained in young clover is more digestible than that in older plants, as shewn by the following data obtained by *Kühne*. Of the following constituents present there were digested:

	Cut on 20th May. Before flowering.	Cut on 7th June. Flowering beginning.	Cut on 20th June. Flowering almost past.
Albuminoids	70.9 %	65.0 %	58.8 %
Fibre	50.6 %	46.6 %	39.8 %
Non-nitrogenous extractives	70.2 %	68.4 %	66.3 %

In another set of experiments made on green clover cut at different stages of growth, the following result was obtained:

	Quite young.	Before flowering.	During flowering.	After flowering.
Fibre digested	60 %	53 %	50 %	39 %

Voelcker's experiments show that the maximum produce is obtained by cutting twice a year; cut three or four times, the produce is less; if 5 or 6 times, still less; but if only once cut the smallest yield is obtained. At the experimental station of Tharand, near Dresden, red clover was cut 6 times between 29th May and 24th June to imitate depasturing by cattle. Clover cut in this way was examined and compared with another sample taken from a part of the same field which had only been cut twice viz. on 7th July and 24th August. The following were the results per acre: —

	Dry substance.	Albuminoids.	Fibre.
Clover mown six times	4678 lbs.	984 lbs.	1020 lbs.
Clover mown twice	9297 ,,	1219 ,,	3126 ,,

It is thus evident that frequent cutting or depasturing reduces the yield, stunts the growth and shortens the life of the plant.

Red clover is generally used in the green state. Conversion into hay is always associated with a certain amount of loss, depending upon the weather and the system of hay-making.

The leaflets as they dry become brittle and readily break off. If the system of haymaking involves frequent moving and turning, the loss of leaf is evidently proportionally great. The leaves form at least one-fifth of the whole produce, and have greater nutritive value than the other parts of the plant; it is consequently clear, that, by the loss of leaf, more than one-fifth of the nutritive matter is lost. The loss of nutritive matter is actually about one-third of the whole.

Dietrich examined the relative percentage weights of leaf, stem, and flower-heads at different stages of development. His results were as follows: —

	31st March. Leaves forming.	26th April. Stems forming.	19th May. Buds forming.	1st June. Flowering beginning.	16th June. In full flower.	30th June. Flowering finished.
Leaves . . .	40 %	41 %	24 %	24 %	19 %	18 %
Leaf-stalks . .	60 %	29 %	14 %	12 %	11 %	10 %
Stems . . .	—	30 %	58 %	58 %	59 %	60 %
Flower-heads . .	—	—	4 %	6 %	11 %	12 %

Ulbricht's experiments shew that, weight for weight, the leaves contain three times as much albumin as the stem. The best system of hay-making is clearly that in which the hay is turned as little as possible, so as to reduce loss of leaf to a minimum; hay-making by drying in the sun is not advisable, as the plants require several turnings; after such treatment the bulk of the produce consists of naked stems.

It would be better to resort to the method of *drying by air*. The crop is cut by the cradle scythe, allowed to lie in swathe for two days, and then formed into rows (stooks) as in fig. 9, page 13, Drying in sheaves is likewise advantageous but involves more labour. In districts where drying can only be accomplished with extreme difficulty, *brown hay* may be made. Red clover is, most conveniently dried on the *clover perches* recommended by *Schwerz*. Within recent years, however, clover pyramids (fig. 12, page 14), have come into general favour in Germany.

Yield.

The yield varies within wide limits and depends upon the nature of the soil, its conditions with regard to manure, the season, etc. *Block*, from forty years' experience of clover growing, states that, on an average, only three full harvests can be obtained in four years, as the yield gradually falls off. *Werner* estimates the average annual produce of hay at 48 cwt. per acre; *Kraft*, at 32 cwt., but, if the land is good and the season favourable, the yield may rise to 56 or even 80 cwt. per acre. *Schwerz* reckons the average yield at 40 cwt.; *Sprengel* at 48 cwt. in a moist season, and about 32 cwt. in a dry one. According to *Langethal*, the average yield obtained from land little suited for clover growing is 32 cwt. of hay per acre; if the land is good, 48 cwt., if good and containing lime, 64 cwt.; in favourable years, the best clover land yields 80 cwt. and over. *Häni* states that, under favourable conditions, red clover yields from 56 to 68 cwt. of hay per acre.

Nutritive value.

100 lbs. of the red clover, cut when in flower, give about 20 lbs. of hay. Green clover in flower contains 80 % water, while hay of good quality countains only 16 %. One part of hay is equivalent to five parts of green clover, but not in nutritive value because a certain percentage of the more nutritive leaves has been lost during hay-making.

The following is the average composition *(Wolff)*: —

Quality	Organic matter	Albumin	Fibre	Non-nitrogenous extractives	Fat	Proportion digested Albumin	Proportion digested Carbohydrates	Proportion digested Fats	Proportion digested Ratio of albuminoid to non-albuminoid matter
	%	%	%	%	%	%	%	%	%
A. Hay.									
Low quality	79.9	11.1	28.9	37.7	2.1	5.7	37.9	1.0	1 : 7.1
Medium quality	78.7	12.3	26.0	38.2	2.2	7.0	38.1	1.2	1 : 5.9
Very good quality	77.5	13.5	24.0	37.1	2.9	8.5	38.2	1.7	1 : 5.0
Excellent quality	76.5	15.3	22.2	35.8	3.2	10.7	37.6	2.1	1 : 4.0
B. Green.									
Before flowering	15.5	3.3	4.5	7.0	0.7	2.3	7.4	0.5	1 : 3.8
During flowering	18.3	3.0	5.8	8.9	0.6	1.7	8.7	0.4	1 : 5.7

Clover cropped from a good soil contains more nutritive matter than that taken from poorer land. *Werner*, in Poppelsdorf, obtained more milk by feeding cows on green clover than by using a corresponding quantity of clover hay. This agrees with the experience of other agriculturists. For milk-production, red clover should, as far as possible, be used green. If hay is desired, a mixture with other fodder plants is preferable to a pure sowing.

Seed-harvest.

Harvesting, impurities and adulterations of seed. For a seed crop dry light soils are better than those that are heavy and moist. On the latter, the plants are readily laid and the flowers are then liable to be barren. Clearly, dry warm climates are more suitable than mountainous or maritime districts with moist atmosphere and frequent rain. Countries of the latter type require to import most of the seed used. A thin crop which has not been laid gives the largest yield of seed. Accordingly the second crop is generally used. It is neither so luxuriant nor so liable to be laid as the first, and the seed from it is purer, as it contains less weeds than the first crop. In mountainous, maritime and northern countries where the second crop ripens late, the first cutting should be taken somewhat earlier than usual to allow the second crop sufficient time to mature its seed. In some countries, notwithstanding this precaution, the seed of the second crop does not reach maturity at all. The first crop must then be used.

In any case, those parts of the field are selected where the clover is least luxuriant and has not been laid. If flowering takes place while the clover is laid, little seed is produced.

The seed is ripe when the flower-heads are passing from brown to black and the seed itself is hard. Heads late in flowering contain soft or merely leathery seeds while those of the early heads are quite hard. It often happens, especially in a moist season, that adventitious branches spring out from the base of the stem and bear flower-heads. Such late heads are not to be taken into account in judging the ripeness of the seed, although the branches themselves must be considered as they interfere with, and retard the drying of the plants. The number of such adventitious branches and flower heads is constantly increasing as maturation advances. When ripe, the plants are cut with a cradle-scythe in very small swathes, which, in good weather, are left untouched for two days, then turned; if the weather continues good, the crop may be housed two days later. In Germany, the ripe plants are dried for two days and then arranged in two long rows (fig. 9, page 13). At times, small bunches bound round with a few culms are formed as in fig. 7, page 13. If rain is likely to set in, the latter plan is preferable, as the seed soon becomes discoloured, often red and shrivelled when the flower heads are allowed to lie on wet ground. The seed of Swiss clover is often discoloured in this way. To obtain good seed, it is sometimes advisable to dry the plants on the clover perch (fig. 10, page 13). When seed is obtained from wild clover plants growing in meadows, the preliminary drying is difficult as more grass than clover is present. In this case the *clover-comb* should be used. In its simplest form, the instrument is merely a rake with close teeth which pulls out the clover-heads and drops them into a bag fixed on the back. Larger instruments are often fitted with a pair of wheels to allow ready movement. All the seeds are not obtained when the clover-comb is used, as many flower-heads fall on the ground and others, as well as many isolated flowers which have broken away from the heads, escape the teeth. After removal of the clover seed which takes a good deal of time and labour, the grass is made into hay.

Many seeds are also lost when the ordinary system of hay-making is followed, as the flowers have brittle pedicels and readily detach in consequence of the moving and turning necessary to prepare the hay. To secure the full amount of seed necessitates, therefore, in all cases, very great care.

The best plan is to use a threshing machine and thresh the seed out of the capitula in the field, receiving it in cloths. If that cannot be done, the plants are carefully carried to the barn in covered carts and threshed when convenient. In threshing, the difficulty is to get the seed out of the flower and the pod; the flower itself readily detaches from the flower-head as its pedicel is brittle. If a shelling machine is not at hand, repeated threshing alternated with winnowing is necessary to extract the seed and remove the debris and pods. With each threshing the quantity of seed obtained diminishes; the operation must usually be repeated about a dozen times to secure all the seed.

This is excessively troublesome work and almost impossible in damp weather as the flowers absorb moisture from the atmosphere and become quite spongy. Threshing is easier in winter when the weather is cold and dry; if delayed till the following summer, the flowers can be dried in the sun. A very good plan for extracting the seed when it is dry, consists in passing the flowers through a pair of millstones from with the hopper has been removed to allow hand-feeding. The *clover-rubber* is a very useful instrument, but it often removes the radicle of the embryo, thus destroying the germinating power. When such a seed is set, the cotyledons swell and fall asunder. The most perfect apparatus for freeing the seeds from the pods is the *clover shelling machine*. Many forms are in the market; that of *Carrow* of Prague is one of the best. All these machines are very expensive.

If the clover contains a large proportion of ribgrass *(Plantago lanceolata)*, it is advisable to remove this impurity by the sieve before shelling the seed. After shelling, ribgrass cannot be cleaned out, as the seeds are almost of the same size as those of red clover. Threshing, sufficient to remove the seed of ribgrass from their capsules, only breaks up the clover heads into flowers; at this stage, cleaning is easy, as ribgrass seeds are much smaller than clover flowers. By this mode of procedure other weeds, especially docks *(Rumex obtusifolius*, L., and *pratensis*, Mertens and Koch) are eliminated. In Emmenthal, where ribgrasses and docks abound in the deep soil, this plan is usually followed. Such cleanings consist almost exclusively of the seeds of ribgrass, a small quantity of dock and a very few seeds of clover which have been threshed from the flowers.

Yield of seed.

Häni reckons the yield of seed per acre at 170 to 300 lbs., *Krafft* at 300 to 450 lbs., *Sprengel* at 350 to 500 lbs., *Langethal* at 200 to 400 lbs. or more, and *Werner* at 250 to 440 lbs. In Flanders, *Schwerz* estimates the average yield at 300 lbs. per acre.

Impurities.

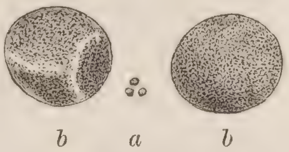

Fig. 55.
Dodder.
Cuscuta Trifolii, Bab.
(see c. epithymum, Murr.)
a. Seed, natural size.
b. The same, × 12—15.

The dodder *(Cuscuta Trifolii*, Bab. or *Cuscuta epithymum*, Murr.) is an impurity unfortunately too common. This dreaded parasite often causes great havoc among clover crops.

About 90 per cent of the seed of Silesian and Austrian clovers is infested by dodder, unless the seed has been specially cleaned. Many attempts have been made to devise a machine which will remove the seed of this parasite. *Fellenberg* of Hofwyl first invented and used such a machine, about the beginning of this century. *Walz* of Hohenheim followed his example and now there are many makers. Long experience has convinced us that the machines made at Herisau are the best. Dodder-seed is usually smaller than that of red clover. The skin is pitted and has one or two flat surfaces. The embryo is spiral and without cotyledons. The following percentage of samples of red clover seed examined at the Swiss station contained dodder: —

1877/78	46.5 %	of the total samples examined
1878/79	38.9 %	,, ,, ,, ,, ,,
1879/80	39.5 %	,, ,, ,, ,, ,,
1880/81	37.7 %	,, ,, ,, ,, ,,
1881/82	32.9 %	,, ,, ,, ,, ,,

Probably the better qualities of seed were sent for analysis; the worse kinds would usually be kept back. From these results, it is clear, that, in Switzerland, the proportion of red-clover seed containing dodder is diminishing year by year.

The impurities most abundant are ribgrass *(Plantago lanceolata*, L.) and dock *(Rumex obtusifolius*, L.); sorrel *(Rumex acetosella*, L.), selfheal *(Prunella vulgaris*, L.), bristle-grass *(Setaria glauca* and *viridis,* P. Beauv.) and field chamomile *(Anthemis arvensis,* L.) also occur. We have never noticed seeds of clover rape *(Orobanche minor,* Sutt.).

Adulterations. Adulteration is now rarely attempted. Hop trefoil (*Medicago lupulina)* (fig. 56), which only costs half as much as red clover is sometimes used for this purpose. The seed of this is yellow and the radicle is acutely pointed and projecting at the apex; it is also recognised by its very bitter taste and characteristic odour. White and yellow melilots *(Melilotus alba,* Desr. and *officinalis,* Desr.) are more rarely used as adulterants. These seeds are yellow and the taste markedly bitter-sweet. Melilot seed is very readily recognised by the odour of coumarine, the substance which gives the characteristic odour to sweet-scented vernal grass.

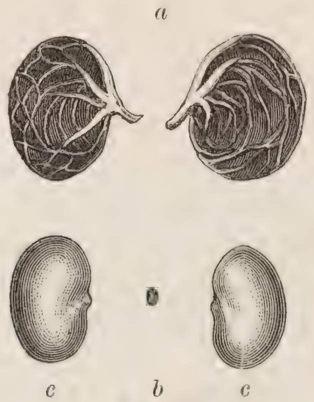

Fig. 56.
Trefoil.
Medicago lupulina, L.
a. Pod with persistent calyx × 7.
b. Seed, natural size.
c. Seed × 7.

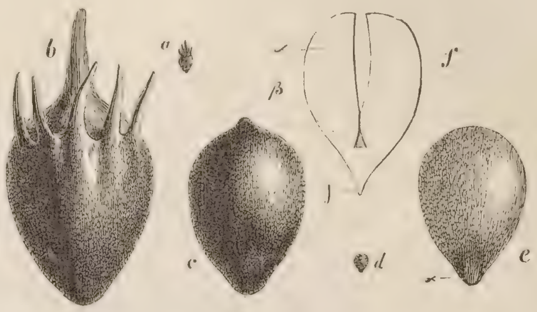

Fig. 57.
Ambrosia artemisiæfolia, L.
a. Fruit with calyx, natural size. *b.* The same, × 7. *c.* Fruit without the calyx. *d.* and *e.* Seed.
f. Longitudinal section of the seed.
α. Cotyledon. *β.* Plumule. *γ.* Radicle.
(After Nobbe.)

Small stones are sometimes used as adulterants. Italian clover seed is often »doctored« in this way. A peculiar kind of sandstone is wrought at St. Angelo in Upper Italy. The grains of sand which compose it are almost identical in size with red clover seed, and, when artificially coloured, they are added to it. The seed of Bohemian clover sometimes contains sand grains. At Hamburg, a manufactory was actually established for producing stone clover seed to be sold to seedsmen for mixture with red clover seed.

Substitution of clover seed from one country for that from another is more common. American seed, for example, is often sold as English or German seed. As already noticed, American is inferior to European seed; as it is cheaper, it is often advantageous for the seedsman to substitute the former for the latter. The seeds themselves cannot be distinguished but there are other marks by which such a substitution may be detected. A frequent impurity of American seed is *Ambrosia artemisiæfolia,* L., (fig. 57) and *anthocarpa,* L.; if the seed of these plants are found, the clover seed is certainly American. The seed of the American variety of ribgrass *(Plantago major*, L., var. *americana)* is a less characteristic impurity; it is twisted into a helix. *Panicum capillare,* L., is frequent in American seed, but this and several species of finger-grass *(Digitaria)* are also found in red clovers from Southern Europe. American seed almost invariably contains seeds of the dock (*Rumex obtusifolius,* L.), knotgrass *(Polygonum Persicaria,* L.*)*, Timothy, etc. Dodder and stony ingredients are rare in American seed.

Italian red clover seed is frequently sold as Styrian seed. The former is readily distinguished from all other varieties by its bright yellow colour and the smallness of its seeds. Its germination is usually very high, but common impurities are *Helminthia echioides,* Gærtn., and small pieces of sorghum and panic grasses.

Red clover from southern France is known by the greyish blue colour of many of the seeds. The seeds of vervain *(Verbena officinalis,* L.*)*, bristle grass *(Setaria viridis,* P. Beauv.*)* and many small stones frequently occur as impurities.

Seed quality.

Seed and amounts to be sown. The average purity of 1500 samples examined at the Swiss station was 96.7 %, and the germination 91.0 %. Of the hard seeds one half were reckoned as capable of germinating. Good commercial seed should have 98 % purity and 90 % germination. The seed should be clean and free from dodder. One lb. of seed usually contains about 279,000 grains. One bushel weighs on an average 64 lbs. The weight per bushel is of course higher when the seed contains sand or small stones. When the seed is kept for a number of years, the germination diminishes and the colour changes to a drab which afterwards passes into red.

Amount to be sown.

The amount of seed to be sown is, on an average, 18 lbs. per acre equal to 15.84 lbs. of pure and germinating seed. On dry, poor and badly tilled soil, more seed must be used than on well tilled and fertile land. If the sowing is too thick, the clover is liable to be laid and then readily becomes rotten. The price per pound is 6 to 10 pence; seed for one acre (18 lbs.) costs about 10 to 15 shillings.

Sowing.

Red clover is usually sown in the months of March or April. Sowing should take place early enough to allow the seed the abundant moisture which is necessary for germination, and to prevent the destruction of the young plants by the fly. If sown late and drought happens to set in, a great many plants are lost. Sometimes, but rarely, autumn sowing with winter wheat is resorted to. In that case, the soil should previously be lightly harrowed and afterwards rolled. The clover drill is very suitable for sowing red clover.

A thickly sown cereal is easily laid, and the clover beneath is, to a large extent, killed from want of air and light. In such a case, when the cereal is cut, the clover is very thin, and the land, in part, quite bare. To remedy this, a mixture of 90 % clover along with 10% of Italian ryegrass and timothy may be sown on the bare patches. To establish a first class clover ley, the clover should be sown with an oat-crop to be cut green. Clover can be grown quite well under flax or rape.

Mixtures.

Red clover is excellent as green fodder, but, as already mentioned, it is not so suitable for hay. If hay is desired a mixture with grasses is preferable to the pure clover as the crop is more certain and the yield larger. Where the clover by itself is uncertain, a mixture containing from 50 % to 90 % of clover should be grown. For temporary leys about 30 %, and for permanency not over 10 % of red clover should be used.

Rotation.

Rotation and clover-sickness. In the old three years' system of rotation clover took the place of the bare fallow. The rotation then was: 1. Wheat, 2. Barley, 3. Clover. On this system, the land becomes unclean, the cereal crop following the clover is poor and the clover itself does not suceed every third year. This led to the practice of putting clover into the same field every sixth year, a root crop taking its place in the third year after the clover. This rotation is: 1. Wheat, 2. Barley, etc., 3. Clover, 4. Wheat, 5. Barley, etc., 6. Root crop. This course of cropping is bad because two cereal crops — wheat and barley — following one another render land very unclean and poor. On the recommendation of *Thaer* recourse was had to the Norfolk rotation: — 1. Root-crop, 2. Barley, 3. Clover, 4. Wheat. The clover is sown in the barley and their following a well-manured and well-cleaned root crop excellent results are obtained. The wheat coming after the clover is also good. Experience of the four course system soon showed, that clover would not succeed every fourth year, for the land becomes »clover-sick«. On some soils it will not succeed even with intervals of six years; nine to twelve years must elapse to secure a good crop. When land is »clover-sick«, the clover dies away in the second year of its growth, without apparent cause. *Liebig* regarded »clover-sickness« as due to the exhaustion of the appropriate mineral matters in the subsoil. *Linde* disputed this opinion, but it has again been advanced by *Kutzleb*. He regards »clover-sickness« as resulting from a diminution of potash in the soil, and, more particularly, from the absence of a sufficient amount of soluble potash in the subsoil. In his experiments, the potash was extracted from the soil by means of water charged with carbonic acid. The extract from 100,000 parts of air-dried soil, was found to contain the following amount of potash: —

		Soil from a depth of ½ inch — 6 inches.	Subsoil at a depth of 1 — 2 ft.	Subsoil at a depth of 2 — 4 ft.
Field at Wingendorf *»clover-sick«*	A.	1.0924	1.7814	1.2854
	B.	1.0982	1.2217	1.1717
Field at Braunsdorf *good clover land*		2.2080	4.0395	1.4436

Further research in this direction would be very interesting.

Experience has also shewn that red clover cannot usually follow a crop of any plant which, like itself, belongs to the family Leguminosae *e. g.* Beans, Vetches, and other clovers (Carnation clover especially).

Clover as a preparatory crop.

Clover is an excellent preparation for cereals, especially wheat. A good clover crop, in fact, implies a good wheat crop. It is not advisable to allow clover to occupy the land for two years as the land deteriorates in the second year and the following cereal crop is not so good. Root crops, tobacco and Indian corn can also be successfully grown after clover.

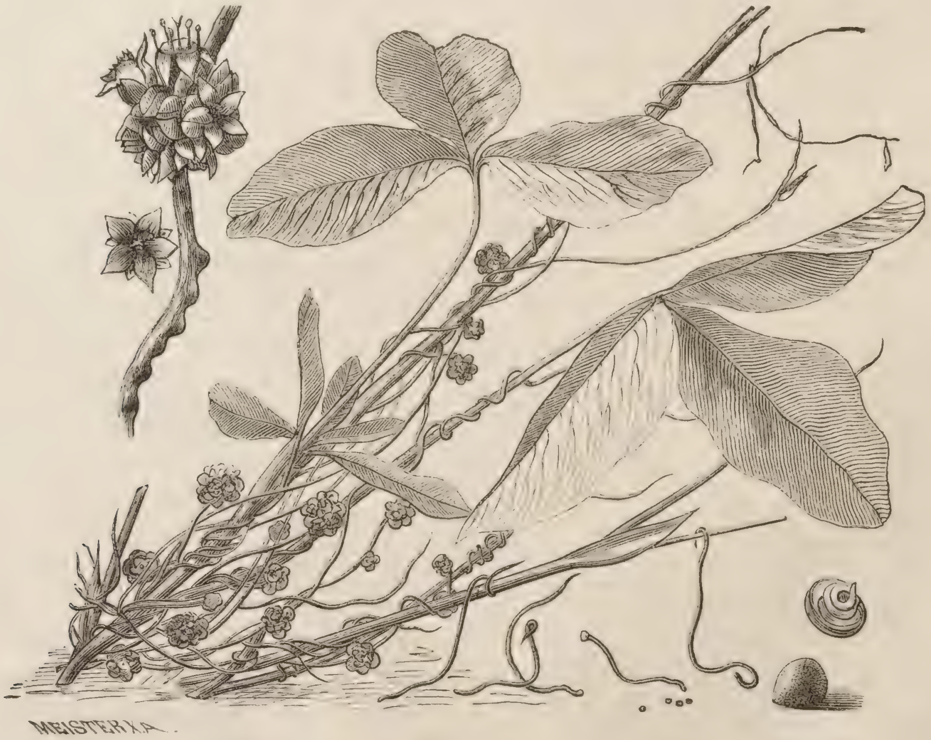

Fig. 58.
Dodder, *Cuscuta trifolii*, Bab. showing dodder growing as a parasite on red-clover; the seed, the young plant and the flowers are shown magnified 7 times.
(After Nobbe.)

Parasites.

Dodder *(Cuscuta trifolii,* Bab.), (fig. 58) is the enemy most to be dreaded. Space does not permit us to give in detail the life-history of this parasite, and the means to be taken for its prevention and destruction. Later, we hope to give a full account of it. Dodder usually gets into land as an impurity of clover seed. It germinates in the soil, and developes a thread-like stem which winds round the clover plant; from the thread-like stem numerous roots *(haustoria)* are produced, these are inserted into the tissues (soft bast) containing the nutritive juices, and the clover plant is sucked dry and killed. At first, the parasite takes a slight hold on the ground, but, as soon as it fastens on a clover plant, the part in the ground dies away, and the parasite lives entirely at the expense of the clover host. Various means have been recommended for its destruction.

Another parasite is clover-rape *(Orobanche minor,* Sutt.). It often does considerable damage to the second crop. The roots of the parasite penetrate the soil and insert themselves into the clover roots from which they drain the nutriment required for their own purposes; in this way, the clover is killed. Some authorities assert that clover-rape can be destroyed by cutting the crop early and manuring with superphosphate, etc. In any case, clover rape should never be allowed to ripen its seed and any field on which it has broken out should be sown with a grass mixture, instead of clover.

In certain districts of north Germany, a parasitic fungus, *Peziza ciborioides,* Fries., attacks clover and often does considerable damage (*Rehm*). Clover is also liable to various other fungoid diseases.

A microscopic nematode worm, *Anguillula devastatrix,* Jul. Kühn., sometimes causes the rotting of clover.

XXV. White clover.

Trifolium repens, L.

Explanation of plate.

Fig. A. Entire plant, in flower, shewing — the creeping stem giving off roots, the leaves, the peduncles and flower-heads. The peduncles are shortened to bring the flower-head into the plate.
,, 1. The flower with its pedicel, seen from the lower surface.
,, 2. The same, side-view.
,, 3. The same, with the calyx removed.
,, 4. The same as in fig. 3, with the standard removed.
,, 5. The same as in fig. 4, with the wings removed.
,, 6. The calyx and corolla removed, shewing the stamens.
,, 7. The pistil.
,, 8. The four-seeded fruit, crowned by the persistent style.
,, 9. The seed, from the broad side, shewing the radicle.
,, 10. The seed, from the edge, shewing the hilum.

Botanical description.

Botanical description. The *stem* is solid, and creeps along the ground. As it runs along, it produces many branches, and gives off roots from the nodes. Each branch bears a few leaves with very long petioles. The long peduncles terminated by the flower-heads spring from the leaf axils. In fig. A the peduncle is made shorter than the petiole, to admit the flower-head to the plate. The *leaflets* are ovate or obovate, with finely toothed margins. The *stipules* are membranous and acute. The flower-heads or *capitula* are globular, solitary, and without bracts (ebracteate). Before and during flowering, the *pedicels* are erect; afterwards they bend downwards. The capitulum (to the left, fig. A) consists of two distinct parts; — the older outer portion with the pedicels and flowers reflected, and the younger central portion with the pedicels and flowers still erect. After flowering all the pedicels and flowers become reflected. The *calyx* is glabrous, ten-ribbed and about half as long as the corolla;

the teeth are fine, lanceolate and acute; the two upper are slightly longer than the others (figs. 1 and 2). The *corolla* is white or rose-coloured, and its parts are very slightly united. The *standard* (figs. 1, 2, 3) has a broad claw, which partially embraces the other petals; its limb is somewhat erect, and folded along the median line. The claws of the other petals, which form the wings (figs. 1 to 4), are adherent, for the greater part of their length, to the stamen-tube. The limb of each wing has a vesicular outgrowth from its base, directed backwards and transversely, over the stamen-tube. At a point in front of this the wings adhere to the keel. The *keel* (figs. 5 and 6) is open, and contains the anther and the free portions of the stamen-filaments. The *ovary* is long and contains three or four ovules; the *style* is curved upwards, and sufficiently long to bring the *stigma* beyond the anthers (fig. 7).

Experiment has proved that white clover cannot be efficiently fertilised without the aid of insects. One of Darwin's experiments showed that ten heads of flowers, visited by bees produced 10 times as much seed as an equal number of heads protected from such visits by a net. Another experiment showed that 20 capitula covered by a net produced only a single bad seed, whereas an equal number of capitula visited by insects produced 2290 seeds. These experiments show that white clover can only be self-fertilized to a very slight extent, and that consequently most of the seed is produced by *cross-fertilization.*

White clover like red clover is adapted for insect fertilization. There are, however, several important points of difference between the two. In the case of white clover, the petals do not unite to form a long tube, and the calyx tube, — by the length of which the amount of opening of the petals is determined — is only 3 mm. long. These arrangements allow insects with short probosces to have ready access to the honey. The honey is secreted at the base of the stamen tube. Two narrow slits lie one to the right and one to the left, at the base of the upper free stamen; the honey is sipped by the insect through these two slits.

As in red clover, so here, the insect lands upon the wings of the flower; its weight presses down the wings and the keel, which adheres to them; the anthers and stigma are thus laid bare and come into contact with the body of the insect. The stigma receives pollen brought from another flower on the insect's body, and, at the same time, more pollen becomes attached to the under surface of the insect's head. When the insect flies away, fertilization has been accomplished and the parts of the flower return to their normal position.

The *fruit* is a flat pod, much longer than the calyx, and crowned by the persisting style. The pericarp is thin and contains three to four seeds (fig. 8).

The *seed* resembles that of alsike, but the radicle occupies almost the whole edge (figs. 9 and 10); the colour is sulphur or orange yellow.

Varieties.

According to Alefeld, two varieties can be distinguished, viz: 1. the wild variety *Trifolium repens sylvestre,* and 2. the cultivated variety *Trifolium repens cultum.* Botanically, these varieties are not distinct. The cultivated variety is, however, twice as high as the other. It has been stated on good authority, that, in upper Italy, the wild variety lasts longer, and is less sensitive to extremes of climate than the cultivated form imported from the North. In this respect, wild white resembles wild red clover.

Name.

This plant is variously known as white or Dutch clover, white trefoil, creeping trefoil, etc.

History.

For a long time, it has been cultivated in Holland, hence the common name Dutch clover. From Holland, its culture spread, like that of red clover, to Mayence, and the interior of Germany. *Langethal* proves from historical evidence, that before 1759, seed of white clover was obtained from Mayence by the agriculturists of Holstein, for the purpose of improving their pastures. In England, it was in cultivation at the beginning of last century. Its introduction into Switzerland is of recent date.

Agricultural value.

White clover is indispensable for the formation of pastures on low-lying lands. It lasts for three or four years, and when the soil is good, even longer. Although the yield is less, it is superior in several respects to red clover: — it thrives on soils of inferior quality, stands depasturing, liquid manure is more suitable to it, the nutritive value is higher, and stock fed on it are not so liable to swelling. In pastures and, to a less extent, in meadows, it is used for forming »bottom grass«. When its creeping stems and foliage become too luxuriant, as is sometimes the case, it may act injuriously by suppressing other plants; in such cases it might almost be regarded as a weed.

Geographical distribution.

Occurrence, climate, soil, manure. White clover is common throughout *Europe,* from Portugal to the Urals, and from Italy and Greece to Lapland. In *Asia,* it occurs throughout Siberia, Caucasus, Georgia, and along the borders of the Caspian. In *Africa,* it is found in the Azores and the Madeiras, along the shores of the Mediterranean, and at the cape of Good Hope. It is also very common in *North America,* but, whether indigenous or naturalized, it is impossible to say.

Habitat.

It occurs wild in all good pastures; if abundant, it is a certain indication of good land. It is often found on roadsides along with perennial rye-grass. It is one of the principal »artificial grasses« of Northern Germany.

Limits of altitude.

White clover occurs at high altitudes in the Alps. By *Brügger,* it was found at 6000 ft. on the pass of Bernhardin, and by *Hermann Müller,* on the Schafberg at Pontresina, at an altitude of seven to eight thousand feet. In the Bavarian Alps, it occurs at 5500 ft.

Climate.

White clover is much less sensitive to climate than red. Although its roots confine themselves mainly to the superficial layer of the soil, still, drought is borne very well, because the axial tap-root descends further, and absorbs water from the deeper layers. During a dry season, little foliage and few new branches are produced; the old branches do not lengthen, and the growth is confined almost entirely to the principal stem. A wet season favours the growth of foliage and branches, and that is why, in moist warm neighbourhoods, the yield is larger than in those which are cold and dry.

Soil.

White clover succeeds best in a moist soil containing lime and mellowed by humus. If very stiff, the resistance to the roots is too great, and they cannot penetrate. Still, if such soils are somewhat moist, the plant thrives tolerably well. It can also adapt itself to sandy soils, which are not too loose and dry, provided that the surface layer contains sufficient nutriment. It is destroyed by stagnant water, but can bear much moisture. It can, therefore, be grown on good moor-land and drained bogs. It can put up with a tolerable amount of iron, and can be grown on ferruginous soils. Marls, loams, clays and sands, which are moist and contain humus, are most suitable.

Substances removed from the soil.

1000 lbs. of hay remove from the soil: —

Nitrogen	22.5 lbs.	Magnesia . . .	5.9 lbs.
Phosphoric acid .	8.0 ,,	Lime	19.0 ,,
Potash	13.5 ,,	Silica	2.8 ,,
Soda	4.6 ,,	Sulphuric acid . .	4.7 ,,

Manure.

The large proportion of potash and lime in the hay, and the superficial root system of white clover, point to *wood-ashes* as a very beneficial and appropiate manure.

Wood-ash, from trees with deciduous leaves contains 10 % potash and 30 % lime, wood-ash from pine trees contains 6 % potash and 35 % lime.

The potash is absorbed by the superficial layer of the soil, the layer most used by white clover. In consequence of the application of ashes, white clover often springs up where none of it has been noticed before. This gave rise to the erroneous opinion, that white clover originates from wood-ashes. Closer observation shows that in such cases, white clover is actually present, but so small and poor, that it is hidden by the other plants and thus readily overlooked. When wood-ashes are added, growth is favoured, and the poor plants become large and well developed.

Marling and applications of liquid drainings of dung heaps are surprisingly beneficial. The nitrogen and potash in the liquid are absorbed by the superficial soil, and thus placed at the disposal of the clover roots. At the same time, the liquid usually contains a large number of white clover seeds. These germinate and develope new plants, an application of liquid manure is therefore equivalent to a slight sowing of seed.

The residue, left in a barrel which had held such liquid manure, was examined by *Stebler*. One lb. of it when dried was found to contain 5370 seeds of white clover, germinating 62 %. The effect produced by liquid manure is then not entirely due to the nutritive substances which it adds to the soil, but largely to the addition of seed, and consequently of new plants. It is very easy to understand how seeds come to be present in liquid manure. Hay, especially from the second mowing, often contains many heads of white clover, which are in seed. When used as fodder, some of these seeds are digested, but the greater number of them pass with the excrements, and thus their presence in the liquid manure is accounted for. The seeds can remain for weeks in the liquid without injury, because the skin of white clover seed does not readily allow water to enter.

If the soil is rich, an application of gypsum acts beneficially. On poor land gypsum can have no action. If the surface layer has been exhausted by a cereal crop, any white clover succeeding it is imperfectly developed and the yield is small.

Irrigation.

Irrigation succeeds when the land is well drained.

Growth.

Growth, yield, nutritive value. The parent stem sends out creeping branches. These, in turn, again branch, and at intervals give off roots. In very dry, stiff, or poor soils, the branches remain exceedingly short, and the whole growth of the plant is stunted. If the conditions are suitable, the branches become long and extend in all directions. In this way, a large surface of ground is very soon covered.

Development.

If the plant has not been sown with a cereal crop, full development is attained in the first year. Flowering commences early in spring about the month of May; but for the most part white clover comes into flower later than red clover. The former should, accordingly, be mown later than red.

Harvesting.

White clover contains a large quantity of water; consequently, when dried and made into hay, it goes into small bulk. It is even more difficult to dry than red clover, but the leaflets do not fall away so readily.

Pasture.

White clover is generally used as a pasture plant, and that is always the case when it is grown by itself. As pasture it is excellent, it stands frequent depasturing better than any other kind of clover, is readily eaten by stock, and is not so liable to cause swelling as red clover. Depasturing is commenced in spring, as soon as the clover covers the ground sufficiently to allow a good bite. The pasture remains good till autumn.

Yield.

Lobbes states that in Holland five acres of white clover pasture can carry seven milch cows. It is not as suitable for mowing because of its low stature (not over 2 ft.) *Block* estimates that an acre will yield, on an average, 1580 lbs. of hay, and pasturage equivalent to 528 lbs. of hay, making a total equivalent to 2108 lbs. of hay; and that four such harvests may be obtained in five years. On a light soil, the average yield is 1760 lbs., but, on a good soil, 2640 lbs. of hay per acre may be obtained. *Langethal* estimates the yield as only one third less than that of red clover. *Guido Krafft* reckons the yield as varying between 1672 and 2640 lbs. of hay per acre:

Notwithstanding the large percentage of water in the green fodder, the nutritive value of white clover is very high, because the parts used consist of leaves, leaf stalks, and peduncles, not stems.

Wolff gives the following as its composition: —

	Organic matter	Albumin	Fibre	Non-nitrogenous extractives	Fat	Portion assimilated		
						Albumin	Carbo-hydrates	Fat
Hay containing 86 % of dry substance . . .	79.8	14.9	26.4	34.9	3.6	8.4	37.0	2.0
Green fodder containing 19.5 % of dry substance . .	17.5	3.5	6.0	7.2	0.8	2.2	7.9	0.5

Ratio of nitrogenous to non-nitrogenous nutriment, for the hay = 1 : 5, for the green fodder = 1 : 4.2.

Because of the large proportion of water, cattle fed upon it are frequently troubled with diarrhœa. This can be avoided by giving dry fodder along with it. White clover, especially when cropped from land to which gypsum has been applied has been said to favour splenic fever. The high proportion of water and albumin in the clover may have some connection with the disease, as experience has shown that splenic fever is more frequent when animals are highly fed.

Seed harvest.

Harvesting, impurities and adulterations of the seed. White clover produces an abundant crop of seed much easier to harvest than a seed-crop of red clover. The first crop is usually taken as the seed-crop. The field can be depastured till the end of May; then the plants are allowed to grow for seed; or a hay crop may be taken about the end of May, and the second cutting used as a seed-crop. If the field is not used in spring, the seed is mature in August, otherwise not until September. The seed is known to be ripe in the same way as red clover. Drying goes on best, if the plants are left in swathe; if necessary, the drying may be completed on the clover carrier. The threshing is not so difficult as it is for red clover, because the seeds (usually 4 in a pod) come out with great ease.

Yield of seed.

Although the seed is small, the yield is very considerable in a good season. *Schwerz* obtained 350 lbs. per acre, and *Sprengel* from 700 to 900 lbs. *Langethal* estimates the yield at 500 lbs., *Krafft* at from 220 to 450 lbs., and *Werner* at from 260 to 520 lbs., per acre.

When cattle are pastured on white clover, a considerable number of flower-heads are left and run to seed. It is often profitable to harvest these, using the clover-comb (see under red clover).

Impurities.

The following impurities are common in white clover: — Plantain (*Plantago lanceolata*), field chamomile *(Anthemis arvensis)*, sorrel (*Rumex acetosella)*, etc. Of these *Plantago* is injurious if the white clover enters into a hay mixture, but in a pasture it does less damage. At times, dodder occurs as an impurity.

Adulterations.

Adulterations are rarely attempted. When old, the seeds become discoloured and red. To give these the bright yellow colour of fresh seed, they are often rubbed with flowers of sulphur. If the germinating power be tested, the buyer cannot be deceived. Some time ago, *Hirschmann* of Hamburg sent into the market stones coloured yellow to imitate the seed, for purposes of adulteration.

Seed quality.

Seed and amount to be sown. The average purity of commercial seed is 93 %, and the germination 74 %. In this estimate, one third of the hard seeds is reckoned to be capable of germination. Good commercial seed should have 96 % purity, and at least 75 % germination = 72 % of pure and germinating seed. Care should be taken that no dodder is present. One lb. of pure seed contains on an average 740,000 grains. The average weight per bushel is 63 lbs. Seed of good quality should have a bright sulphur yellow colour; if old, it will be red and the germination low.

Quantity to be sown. $10^{1}/_{2}$ lbs. of seed containing 74 % pure and germinating are required per acre = $7^{1}/_{2}$ lbs. of pure and germinating seed.

Sowing. White clover is sown pure only for pasture. It is cultivated in the same way as red clover. *Langethal* states that in *Mecklenburg*, *Pomerania*, *Uckermark and Neumark*, only one cutting is taken during the first year. For the rest of the year, the clover is used as pasture. Next year, it is depastured in spring and then ploughed up.

Mixtures. A pure sowing of white clover is neither so good nor so healthy for stock as a mixture. The pastures in Holstein and Schleswig consist almost entirely of perennial rye-grass mixed with white clover. Some of the best pastures in England have much the same composition. Dutch clover is often grown along with red clover, but the former lasts longer. In a mixture for hay, white clover forms excellent »bottom grass«. It is mixed with other clovers and with grasses either for temporary or permanent leys. Superficial rolling, and, if moss has sprung up, the use of the chain harrow are advisable in spring. A top-dressing of marl, ashes or compost does good service.

XXVI. Common kidney vetch.

Anthyllis vulneraria, L.

Explanation of plate.

Fig. A. The entire plant, in flower.
,, 1. The flower side-view.
,, 2. The same, with the calyx removed.
,, 3. The standard detached, seen from the lower surface.
,, 4. The same as fig. 2, with the standard removed, shewing the wing.
,, 5. The keel and reproductive organs.
,, 6. The same, with one half of the keel removed.
,, 7. The pistil.
,, 8. The calyx, in fruit.
,, 9. The fruit, seen from the side.
,, 10. The same, seen from the ventral surface.
,, 11. The seed, from the side.
,, 12. The same, from the hilum.

Botanical description. The aerial part of this plant is composed of branches developed from lateral buds, which are situated in the axils of radical leaves. At first, each branch is underground, and after growing in a horizontal or oblique direction for a certain distance, it rises into the air and becomes an aerial stem. As a result of this mode of development, a branched underground stem (rhizome) is present; its branches are short and stout, and can in turn produce new buds and branches, which rise into the air. The rhizome is, thus, many-headed, each of its branches representing a head from which secondary branches originate (fig. A).

The *stem* is from 8 to 16 inches long, erect or spreading, more or less pubescent, and produces little foliage. The *leaves* (fig. A) are imparipinnate. The odd leaflet is very large, compared with the paired and opposite lateral leaflets, which often abort from the radical leaf, then composed of the single large terminal leaflet with a very long petiole. The *leaflets* are somewhat thickened and glabrous, except the odd leaflets of the radical leaves, which are downy beneath; the midribs are alone visible, the other veins being concealed in the tissues. The stipules are small and lanceolate.

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The flowers (fig. A) are numerous and clustered at the apex of the peduncle in large capitula — one, two, or rarely three together — with green palmate bracts at the base. The *calyx* is inflated, covered with white down, contracted at the mouth, and two-thirds as long as the corolla. The *corolla* is always yellow, except in one variety which has a tinge of red at the apex of the keel, the colour sometimes extending over the whole corolla. The *standard* (figs. 2 and 3) is not at all conspicuous; the claw is narrow, the limb obliquely ascending and embracing the anterior portion of the wings with its margins and basal lobes. The *wings* (figs. 4 and 5) are very closely articulated with the keel by folds and little teeth, which dovetail into one another, so closely, that, if the wings are pressed down, the keel must go along with them. The *stamens* (fig. 6) are ten in number; all the filaments cohere, almost to their ends, and form a tube completely closed *(monadelphous)*; the free ends curve upwards, and lie in the beak of the keel; the anthers are club-like and packed together at a common level in the beak, to form, as it were, a plug, beyond which is found the shed pollen and the capitate stigma.

The *ovary* is short, stalked and contains two ovules; the *style*, long, thread-like and thickened at the bend, and the *stigma* capitate (fig. 7).

According to *Hermann Müller*, when an insect visits the flower, it inserts its proboscis between the standard and the wings, in order to reach the honey. It alights upon the wings, which along with the keel are pressed downwards by the weight. The anthers in the beak now act like the piston in a pump, and the pollen is squeezed out at the apex of the keel, against the under surface of the insect's body, and attached there. Later, the stigma is also protruded and receives pollen, either that from its own flower, or that brought from some other on the body of the insect. It is not proved that self-fertilization does not occur in the kidney vetch.

The *fruit* is enveloped by the persistent calyx (fig. 8) which is inflated, but closed in at the mouth round the withered remnants of the corolla (fig. 8). Here, the calyx acts as a seed-distributor; being swollen, a large surface is exposed to the wind, and the calyx with its contents is readily carried off. The stalk of the pod is curved thread-like, 3 mm. long, and attached about one-fourth above the base of the ventral suture. The pod itself is one-seeded, somewhat flattened and terminated by a curved beak; the margins are acute, and the surfaces finely reticulated (figs. 9 to 10). The *seed* (figs. 11 and 12) is shining, mottled with yellow and green, slightly flat, ovate and somewhat depressed near the hilum which is round.

Varieties.

Varieties. There are two important varieties. 1. *Anthyllis vulneraria* var. *alpestris*, Heg. The stems bear few leaves, and the flowers are usually of a light yellow colour. This variety occurs in the transalpine region, and at very high altitudes on the Alps, for example, Lüner-See at 6800 ft., and Albula at 7800 ft. It often forms one of the must useful plants of mountain pastures on the Alps.

2. *Anthyllis vulneraria* var. *rubriflora*, Heg. The flowers are more or less tinged with red, but, in other respects, they resemble the preceding. It occurs mainly in the transalpine region. Some authorities unite both varieties into a single species, called *Anthyllis Dillenii*, Schultes, but specific distinction from *A. vulneraria* is scarcely possible.

Name.

The specific name, *vulneraria*, of this plant indicates its reputation in pharmacy as a vulnerary. It is sometimes called ladies'-finger or lamb's-toe.

History.

The species has only been in cultivation for about 30 years. According to *Langethal*, a peasant named *Voigt* noticed it growing wild on the roadsides near Groos-Elbingen in Prussia. He collected the seeds, sowed them on a poor sandy field, which had been marled, and obtained a good crop. He continued to cultivate the plant, and his neighbours soon followed his example. It soon became widely cultivated in the sandy districts of Magdeburg. In 1859 *Langethal* first heard of the cultivation of the plant, and received specimens from this district with stems over 2½ feet in length. Since that time, its cultivation extended North und East, and *Voigt* was well remunerated for his important discovery by the Prussian Government.

Agricultural value.

At the present time, kidney vetch is a very valuable fodder plant on the poor soils of Northern Germany where red and white clover cannot be grown, and where the yellow lupine and bird's foot trefoil *(Ornithopus sativus)* are uncertain and give small produce. It is a plant contented with very little, and as the land does not readily tire of it, the crop can recur after very short intervals. The yield is certain, although not very large; failure is rare, because the plant is not at all sensitive to climatic influences. In stall-feeding during summer, it fills up the gap between the first and second crop of red clover. It can either be mown, or depastured. When mown, it is generally used only for a single year, but if mixed with other plants, it lasts longer. In a pasture, its duration is from three to four years. Since it is very abundant, thrives well on the Alps, and is readily eaten, it could, with advantage, be sown on mountains.

Geographical distribution.

Occurrence, climate, soil, manure. Kidney vetch is indigenous — to the whole of *Europe* except the largest part of Lapland, Finland and Northern Russia; to *Africa,* in Algeria, the Atlas mountains, and Abyssinia; to *Asia,* in Caucasus, Georgia, and the greater part of Asia Minor. It does not occur in *America.*

Habitat.

It grows in a wild state in meadows and pastures, by roadsides, in woods, on mountains, and, in general, wherever there is a sunny exposure and dry ground, especially if the subsoil is marly or calcareous. Its abundance indicates a calcareous soil.

Limits of altitude.

Both varieties ascend almost to the snow-line; for example, at Albula 7800 ft., and at Lüner See, 6800 ft.

Climate.

Kidney vetch is as little sensitive to the cold of winter as to the drought of summer. It is seldom uprooted by frost, even when growing in exposed situations. Clover species do not allow autumn sowing, but kidney vetch is usually sown then and gets on quite well during the winter. It withstands drought as well as sheep's fescue (which see). On excessively dry ground, the plant becomes very woolly.

Soil.

Soils which are too light for red clover are suitable for kidney vetch. On a poor sand, which cannot bear white clover, it thrives if marl and manure are added. It can, in general, be cultivated on all warm soils — marly, loamy, sandy, or calcareous — if they are manured, and of proper depth. Its cultivation is advisable only in cases where red and white clover fail. On cold wet soils and moors it does not thrive.

Substances removed from the soil.

According to *Wolff,* 1000 lbs. of hay remove from the soil:

Nitrogen	22.8 lbs.	Magnesia . . .	2.2 lbs.
Phosphoric acid .	4.4 ,,	Lime	33.7 ,,
Potash	12.3 ,,	Sulphuric acid . .	1.0 ,,
Soda	1.3 ,,	Silica	1.5 ,,

According to analyses made at the Swiss station, 1000 lbs. of hay remove from the soil: Nitrogen 20.5 lbs. mineral matter, 90.2 lbs. composed of: —

Phosphoric acid .	9.2 %	Lime	24.9 %
Potash	25.4 %	Sulphuric acid . .	2.8 %
Soda	1.1 %	Silica	16.2 %
Magnesia	3.0 %		

Manure.

From the above, this plant evidently requires a great deal of lime. It exacts little from the soil, but some preparation is necessary. It is not content with a poor soil containing no manure, although its strong and deep root-system allows it to take no inconsiderable portion of its nutriment from the subsoil. Direct manuring is usually not advisable, the plant should rather follow other crops which have been manured; in that case, the young plant developes more strongly, and more branches are produced. Marling is advantageous as a lime supply.

Growth.

Growth, yield, nutritive value. The stem is usually ascending. If the plants have plenty of room, the branches spread along the ground, but if close together, the stems become more erect. Thick sowing should therefore be used to get the plants as erect as possible. Branches spring out from one another beneath the ground, interlace with those of adjacent plants, and kidney vetch can in this way almost completely cover the ground with vegetation. The stems in the air also give off branches and produce a good amount of foliage.

Development.

During the first year, simple radical leaves above ground with long petioles are alone produced, in the second, the aerial stems bearing compound leaves become developed. If sown under a cereal, this plant makes so little headway by the time the cereal is harvested, that only under very favourable conditions can the produce be used even for pasture. When not depastured, it stands the winter better, and produces more branches. In spring, it begins to vegetate about the same time as red clover, but it developes more slowly, and flowering is, therefore, somewhat later.

Harvest.

To obtain two cuttings in a season, the first must be taken before flowering, but if only one cutting is to be taken, and the after-growth used as pasture, it is more advantageous to commence mowing, as practical experience has shewn, when the plant is in full flower. In this case, the aftergrowth produces no new stems, but leaves merely. If the first cutting is desired later in the season, depasturing can go on in spring, without any diminution of the hay crop.

Hay is made like that of red clover. Great loss may ensue from the falling away of the leaves, and from the action of rain. The amount of loss due to rain is shewn by the following analyses. In one case, the hay was dried and then housed; in the other, it lay in the rain for three weeks.

According to *Beyer*, 100 lbs. of the dry substance contained:

	Hay not exposed to rain.	Hay exposed to rain.
Nitrogenous matter	11.9 %	8.7 %
Fat	3.2 %	1.0 %
Fibre	36.2 %	39.9 %
Non-nitrogenous extractives . . .	42.6 %	45.7 %
Mineral matter	6.1 %	4.7 %
	100 %	100 %

It is thus clear, that rain causes considerable loss of nitrogenous matter and fat — the most valuable constituents of the fodder.

Yield.

The yield of hay varies according to the soil. *Werner* obtained from a pure sowing made on a good sandy loam, containing marl from 5280 to 8800 lbs. per acre = 48 to 80 cwt.; from a light, calcareous, good sand 3520 to 5280 lbs. = 32 to 48 cwt.; from a poor sandy and silicious soil from 1760 to 2640 lbs. = 16 to 24 cwt.; on an average 3960 lbs. = 36 cwt. per acre. *Langethal* reckons that from 2640 to 3520 lbs. = 24 to 32 cwt. represents the yield. *Schulze-Sammenthin*, from a soil of the worst kind, obtained 2100 lbs. = 19 cwt. and from a better, class soil 4400 lbs. = 40 cwt.

Nutritive value.

According to *Wolff*, 100 lbs. of hay contain 79.4 of organic matter composed of:

Nitrogenous matter	14.2 %	portion digested	8.2 %
Fat	2.6 %	„ „	1.4 %
Fibre	26.3 %	„ „	36.8 %
Non-nitrogenous extractives	36.3 %		

Ratio of nitrogenous to non-nitrogenous nutriment 1 : 4.9.

The proportion of nutritive matter contained in this plant is thus greater than in red clover hay of medium quality.

According to the Swiss results, 100 lbs. of hay contain of 76.7 organic matter composed of: —

Nitrogenous matter (Nitrogen × 6.25) (albuminoid-nitrogen 1.29 %, non-albuminoid nitrogen 0.75 %)	12.8 %
Fat	1.9 %
Fibre	36.4 %
Non-nitrogenous extractives	25.6 %

The fodder is readily eaten by sheep, goats and cattle, but not by horses. It acts as an astringent, an action probably depending on the large proportion of tannin in the plant. It does not produce flatulence.

Harvesting the seed.

Harvesting, impurities and adulteration of the seed. It is important to select the right time for cutting, for if cut too early, threshing is difficult, and if too late, a quantity of the seed falls off and is lost. In this case the first produce is allowed to develope and ripen for seed. Usually, seed is ripe by the beginning or middle of August. The plants should be cut when the pods are partly black and partly dark green. Further procedure is the same as for red clover. The dried flowers and the pods which they contain, are readily threshed off, but the removal of the seeds from the pods causes some difficulty. A threshing machine to which a clover-rubber has been attached is good for shelling, the clover shelling machine is even better for the purpose. Sometimes unshelled seed, at times even ripe flowers, are used for sowing.

Yield of seed.

Werner estimates that the yield of seed per acre varies between 350 and 700 lbs., i. e. on an average, 440 lbs. per acre.

Impurities and adulterations.

The seed is green on one side and yellow on the other, and is very often mixed with trefoil *(Medicago lupulina*, L., fig. 59). Trefoil seed is smaller, greenish yellow in colour, and shows the small tip of the radicle projecting on the surface. Genuine seed may be most readily obtained from Berlin or Breslau.

Seed quality.

Seed and amounts to be sown. Good seed should have 95 % purity and 90 % germination = 85.5 % of pure and germinating seed. One lb. of pure seed contains from 126,000 to 182,000 grains. The bushel varies in weight between 60 and 64 lbs.

Amounts to be sown.

An acre requires 17½ lbs. of seed containing 85.5 % of pure and germinating seed = 15 lbs. of pure and germinating seed. If the seed is contained in the pod unshelled, 22 lbs. per acre are necessary, since 100 lbs. of pods contain 80 lbs. of seed. If the floral envelopes are present in addition to the pods, 117 lbs. are required, as 100 lbs. of pods enveloped by the calyx and corolla contain only 15 per cent of seed.

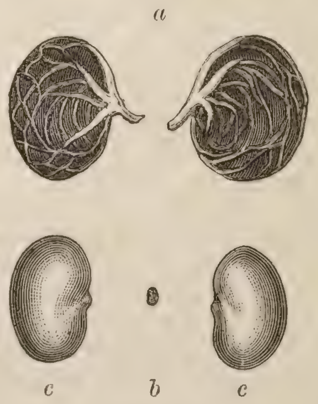

Fig. 59.
Trefoil.
Medicago lupulina, L.
a. The pod, with persistent calyx × 7.
b. The seed, natural size.
c. The seed × 7.

Sowing.

Kidney vetch is best sown in a cereal crop, such as oats or rye, which succeeds a manured root-crop. If the rye is sown early in autumn, kidney vetch may be sown in the same season. For a pure crop, it should be sown as early in the spring as possible, about the end of March, or the beginning of April. Concerning preparation of soil, mode of sowing, and covering the seed, the reader is referred to the remarks under these heads in the article on red clover.

Mixture.

Kidney vetch is used to the greatest advantage in mixtures; it is especially suited for grass and clover mixtures — whether for pasture or hay — of short duration; the most appropriate associates are sheep's fescue, timothy, trefoil, meadow brome, and, in certain circumstances, false oat-grass. Such mixtures are not only more productive, but also more lasting than a pure sowing.

Succeeding crop.

As kidney vetch has a much branched underground stem and is deeply rooted, it leaves behind in the soil more residues than even yellow lupine itself. Within a depth of ten inches from the surface, according to *Werner*, the following amounts per acre of vegetable and mineral matter are left behind: —

	Kidney vetch.	Lupine.
Residues left in the ground (free from water)	4925 lbs.	3470 lbs.
Containing: Nitrogen	100 ,,	61 ,,
Mineral matter . . .	960 ,,	542 ,,
The mineral matter contains: —		
Phosphoric Acid	24 ,,	24 ,,
Potash	26 ,,	17 ,,
Soda	6 ,,	4 ,,
Magnesia	18 ,,	12 ,,
Lime	136 ,,	80 ,,

From these results it follows that kidney vetch has no inconsiderable influence in ameliorating any soil in which it is grown. It is then an excellent preparation for colza and rape, as it can be cut sufficiently early to allow plenty of time for sowing the succeeding crop. It is also a good preparatory crop for cereals.

XXVII. Lucerne.

Medicago sativa, L.

Explanation of plate.

Fig. A. Upper part of a plant in flower.
,, B. A two-headed stock or rhizome. A set of branches is seen springing from each head.
,, 1. The flower side-view.
,, 2. The wing *(ala)*.
,, 3. The keel *(carina)* and the stamen-tube, set free and bent upward.
,, 4. The pistil.
,, 5. The legume, side-view.
,, 6. The legume, from above.
,, 7. The seed, side-view.
,, 8. The seed from the hilum-bearing surface.

Botanical description.

Botanical description. The tap root of lucerne descends to considerable depths (see page 149). The young plant consists of a number of aerial branches springing from a simple basal stock (rhizome) at the crown of the root. These branches ascend directly above ground and form a compact tuft. On the old plant, however, certain of the more robust stems elongate underground and become new branch-producing stocks. In this way, the simple stock or rhizome becomes two- (fig. B) or many-headed.

The *stems* vary in height from one to three feet, are slightly angular, pubescent or glabrous, and branched.

The *leaves* (fig. A) are compound and trifoliate. They are arranged in two ways: — Spirally on the main stem, two-rowed on its branches. The *leaflets* are pubescent and vary in form from oblong to obovate; the apex is emarginate, slightly toothed and mucronate. The *stipules* are acute. The *inflorescence* is an oblong, many-flowered raceme with blue or violet coloured flowers. The *peduncles* are axillary and longer than the leaf. The *calyx* is gamosepalous with five awl-shaped teeth, campanulate, pubescent on the ribs, but otherwise glabrous (fig. 1). The *standard* makes a sharp bend upwards and is slightly keeled in the middle line. The *wings* have a broad claw, from the point at which the claw joins the limb, beside, a fingerlike process extends backwards and inwards so as to grip the stamen-tube; immediately anterior to this is a deep invagination which fits into a corresponding fold of the keel; these folds also grip the stamen-tube. The *keel* (fig. 3) is rounded at the apex and has no beak.

The *stamen-tube* (fig. 3) is composed of nine cohering filaments. When freed from the restraint imposed by the keel (in the manner described below), it bends with great force, carries the stigma and anthers up with it and actually presses them against the standard, so great is the bending force. *Müller's* researches shew that this upward motion is due to the contraction of the upper filaments of the stamens.

The *pistil* is composed of a hairy ovary containing several ovules, a slender style curved upwards and a terminal, bilobed stigma.

The stamen-tube, as pointed out by *Hermann Müller*, is imprisoned by the apendages and folds of the wings and keel; these articulate with one another and with the stamen-tube. The effects produced by the visits of insects are as follows. The weight of the insect disarticulates the parts and sets the stamen-tube free. The upper filaments contract and the stamen-tube carrying the anthers and stigma with it is forcibly bent upward and pressed against the body of the insect. The stigma can now be impregnated by the pollen on the insect. At the same time, the body of the insect and probably the stigma as well are dusted with pollen from the flower.

Hildebrand's researches shew that the flowers of lucerne can form fruit when the visits of insects are entirely prevented. Up to the present time, no one has directly observed an insect in the act of freeing the stamen-tubes. Bees insert their probosces sideways into the flower and extract the honey without freeing the stamen-tube. Since butterflies are the only other visitors, *Hermann Müller* concludes, that they do so. No internal changes going on in the flower can do this, for *Hildebrand* has often observed flowers quite withored in which the stamens had never been released. From these observations, it is evident that the relations between the flowers and their insect guests are not yet understood.

The *fruit* (figs. 5 and 6) is a spiral legume with two or three complete turns, many-seeded, from 4 to 5 mm. long and 3 to 4 mm. thick. The surface is net-veined and covered with adpressed hairs; on its periphery is a projecting rib (dorsal section) which, when the pod dehisces, detaches as a thread twisted on itself.

The *seeds* (figs. 7 and 8) are kidney-shaped (reniform), yellowish-brown, from 2 to 2½ mm. long and one mm. thick. The radicle is very distinct and the hilum occupies a depression on one of the narrow surfaces.

Varieties.

Alefeld and other botanists unite purple lucerne *(Medicago sativa,* L.), intermediate lucerne (*Medicago media,* Persoon) and yellow lucerne *(Medicago falcata,* L.) into a single species, and regard these as three varities. Some authors, however, look upon *Medicago sativa* and *Medicago falcata* as distinct species and consider *Medicago media* as a hybrid between them. Still others regard them as three distinct species. The three forms differ so widely in agricultural value and other characters that they cannot possibly be treated together; here ordinary lucerne *(Medicago sativa,* L.) is alone taken into consideration.

In temperate Asia, especially in the Himalayan mountains, numerous varieties very similar to ordinary lucerne occur.

Hugo Werner has experimented with a Chinese variety *(Medicago sativa* var. *rotundifolia,* Alefeld) which had been sent to Russia, in 1847, under the name of »Mü-Süe«. He found it inferior to our lucerne as the yield diminished considerably after the first cutting.

Name.

The origin of the name »lucerne« is involved in obscurity; it has certainly nothing in common with the Swiss town of the same name, as the plant is only rarely cultivated at Lucerne. Some have attempted to connect it with »Clausert« or »Clauserne« the district in Italy whence it was introduced by the Provençals into France. Historical evidence proves that such is not the case and that the plant was introduced into France from Spain. Others say that the name is derived from the Celtic »Luzu«, »luzuen« = an herb. It is sometimes called »purple medick« to distinguish it from yellow medick and other species of the same genus.

History.

Lucerne is a very ancient agricultural plant and was known to the Greeks and Romans. The Greek name was *Medicai,* the Latin, *Medica* or *Herba medica* — a name still in use in Italy *(Erba medica).* The plant received this name because it was imported from Media, during the war with the Persians about 470 B. C. At that time, it was cultivated in Persia, and used as fodder in the royal stables. In Italy its cultivation commenced about 200 B. C. and soon extended. It is mentioned by *Virgil, Varro* and *Columella.*

From Italy lucerne was introduced into Spain. The ravages of the barbarians retarded, and according to some authors, entirely stopped its cultivation in Italy for a time. It is true that the celebrated *Petrus de Crescentiis* of Bologne, who lived between 1235 and 1320, does not mention it in his work on agriculture, but *Targioni,* who cannot be wrong on this matter, states definitely that lucerne had always continued in constant cultivation in Italy and especially in Tuscany, even from the earliest times. According to *Gallo,* it was introduced into southern France in 1550. *Clusius* introduced it into Belgium in 1565. It was probably brought into Switzerland from southern France.

Agricultural value.

Lucerne is to be regarded as the most important fodder plant in southern Europe, because it thrives and is very productive in warm climates and on dry soils where red clover would be quite dried up. It can be cut earlier in spring than red clover and from three to five good cuttings may be taken in a year. The weather affects it little. Its fodder is very suitable for stall-feeding during summer. The well-being and prosperity of many districts depend entirely on this plant. As *Sprengel* remarks »what would be the condition of the greater portion of the Palatinate, if it had not lucerne?« Its duration varies from 3 to 20 years and depends upon the nature of the soil and climate. In climates where the soil is warm and deep, fields of lucerne from twelve to fifteen years old are quite common; some fields are in their twentieth or even their twenty-fifth year and still the plants are good. If the conditions are unfavourable, the plants usually die out within a period of three years. Cultivation is only profitable when a ley of 5 or 6 years' duration can be relied upon. At the end of the ley, the land is broken up, and a cereal crop follows. As a general rule, it can recur on the same land only after a period of rest equal in duration to the lucerne ley. This interval of time, however, depends largely upon the nature of the subsoil, if this is good, the crop may recur sooner.

Geographical distribution.

Occurrence, climate, soil, manure. Lucerne is indigenous to the following parts of Asia — Anatolia, Southern Caucasus, Persia, Afghanistan, Beloochistan and Cashmere. In *Europe* it is extensively cultivated in Southern France, Northern Italy, Hungary, and the Palatinate. It occurs as an escape from cultivation especially on warm calcareous soils.

Limits of altitude.

At Schleins in the lower Engadine, it is cultivated at a height of 5000 ft. There, it succeeds very well and two cuttings can be taken in a season. In the canton of Grisons, fields of lucerne from 20 to 25 years old are found at altitudes varying from 3000 to 4000 ft. At Obervaz and at Churwalden (4200 ft.) *Brügger* found it growing wild.

Climate.

For successful cultivation, lucerne requires a warm climate and a warm exposure, it therefore thrives best in the maize and vine regions.

It can withstand drought better than other leguminous plants because its roots descend to greater depths. After continuous drought lasting for several weeks, the plant withers if the soil is very permeable to water, but, whenever rain comes on, it immediately recovers and starts afresh.

Wet weather does is more injury than drought; in a wet season, therefore, the crop is not so good as usual. If the district has a heavy rainfall, the plant does not thrive at all. It may, in fact, be assumed that lucerne cannot be successfully grown wherever the annual rainfall exceeds 32 or 36 inches, even though the soil is suitable in other respects. Not only is the rain directly injurious, but weeds are favoured and obtain the upper hand.

It is not sensitive to cold, and temperatures as low as 25° C. below freezing point are said to act injuriously only when the plants are not sheltered by snow.

Soil.

The great essential for the successful growth of lucerne is a good subsoil, not too compact, into the depths of which the roots may easily penetrate in all directions and find the nutriment which they require. The surface soil is of slight importance; it matters little whether it is heavy or light, but the subsoil must be good.

A large amount of lime is another requisite. Accordingly, lucerne thrives best on soils and subsoils rich in this constituent, namely, on loamy and sandy marls and on calcareous and clay marls. It also grows well on loams and clays with a permeable subsoil and even on sands with a good subsoil containing lime. On soils resulting from the weathering of calcareous rocks, it is equally successful, if the subsoil is well decomposed or well broken up; but, if the subsoil is too solid and rocky, the plant cannot be grown. If the soil is good and sufficiently deep, even though the subsoil be gravelly, the plant prospers.

On clays with a stiff and impermeable subsoil as well as on very wet land, the plant becomes diseased and soon perishes.

Substances removed from the soil.

Lucerne seeks its nutriment in the depths of the soil. A striking example of this is referred to by the Swiss naturalist *Bonnet*, who mentions a plant found on the banks of the Arve with a tap-root 66 feet in length.

According to *Fraas*, the roots of leguminous plants can penetrate to the following depths: —

White clover	6	inches
Crimson clover	12	,,
Red clover	25	,,
Lucerne	50	,,
Sainfoin	37 to 150	,,

He remarks that lucerne thrives although the soil be of such a nature that the roots can only penetrate to a depth of 25 inches; if they can get deeper, so much the better for the plants.

According to *Wolff*, 1000 lbs. of lucerne hay, taken at the commencement of flowering, with 14 % water, contains: —

Nitrogen . . .	23.6 lbs.	Magnesia . . .	4.2 lbs.
Phosphoric acid .	7.3 ,,	Lime	34.9 ,,
Potash	21.9 ,,	Sulphuric acid . .	4.9 ,,
Soda	1.5 ,,	Silica	8.2 ,,

The ash is thus very rich in potash, lime and magnesia.

Manure.

It is not advisable to apply farm-yard manure to the land immediately before sowing. Such an application favors the growth of weeds which are often very injurious to the young plants. A much better plan is to introduce the lucerne after a well-manured root-crop. In certain circumstances, however, an application of suitable artificial manure before sowing is not only advisable but very advantageous. Later, a top-dressing of liquid manure, compost, ashes and more rarely of dung, gypsum etc., may be applied. Liquid manure is remarkably favourable to development, but it must not be forgotten that the weeds are also favoured and may easily gain the upper hand. An application of gypsum has, of course, less action on lucerne than on red clover because the roots of the former are so much deeper. It should be applied immediately after liquid manure in order to fix the ammonia. Turf-ashes, rich in sulphate of lime, and even ordinary ashes act equally well, not only serving as a check to the growth of weeds, but directly favouring the development of lucerne. Old compost is also good and should only be applied in autumn. A dressing of stable-dung is not only a waste of manure, but is actually hurtful, because it favours the growth of weeds very much. Experiment has not yet determined at what point the application of artificial manures ceases to be profitable. It is certain, however, that manuring with nitrate of soda to the extent of 40 or 60 lbs. per acre acts very favorably on the growth of the young plants. Its use is, therefore, advisable on recently established lucerne fields in which the plants are slow in coming forward. When the soil contains little lime, marling has a good effect; the marl should be applied in autumn, before sowing.

Growth.

Growth, yield, nutritive value. The stems of lucerne vary in height from one to three feet; they are branched and provided with abundant foliage. The stout underground stock or rhizome has no stolons; all the branches ascend directly into the air. From this mode of growth, it is clear that lucerne cannot cover the ground completely, and that space is left in which weeds can make headway to the serious detriment of the lucerne itself.

When a stem is cut, the stump dies, but the buds on the rhizome, formed while the stems were growing in the air, begin to shoot and soon become new branches.

Development.

During the first year of growth, the root penetrates a loose soil to a depth of about two feet. In a rich soil, full perfection is reached in the second year, but if the soil is poor, only in the third.

In France, Baron *Crud* found the annual yield per acre as follows: —

1st year .	3520 lbs.	(32 cwt.)	4th year .	11440 lbs.	(104 cwt.)
2nd ,, .	10560 ,,	(96 ,,)	5th ,, .	10200 ,,	(93 ,,)
3rd ,, .	11440 ,,	(104 ,,)	6th ,, .	8800 ,,	(80 ,,)
7th year . .	7040 lbs.	(64 cwt.)			

Land under lucerne should be broken up after a ley of from five to seven years because the yield greatly diminishes after that time, as shewn by the above result.

Hecke, from a moderately good lucerne soil at Altenberg in Hungary, obtained the following annual produce of hay per acre: —

1st year . .	3080 lbs.	(28 cwt.)
2nd „ . .	6160 „	(56 „)
3rd „ . .	4840 „	(44 „)
4th „ . .	3870 „	(34 „)
5th „ . .	2290 „	(21 „)
Average	4050 lbs.	(37 cwt.)

Growth commences at the end of April or the beginning of May, when fruit-trees are beginning to flower. The first cutting of the season is ready about two or three weeks before red clover; between and after the red clover crops cuttings are again obtained and all are excellent. For this reason, as *Langethal* puts it, if red clover is regarded as the king among leguminous fodder plants, then lucerne must be considered as his accompanying queen. In a single season, according to the situation, from three to five cuttings may be taken; the second and following cuttings are almost as productive as the first.

It is important always, to cut some time before flowering; if not, the stems harden and, in that condition, are not so readily eaten by stock. Lucerne is most valuable as green fodder. It is less suitable for making into hay, as the leaves very readily fall off, and drying is difficult.

According to *Ritthausen's* experiments, 100 lbs. of lucerne are composed off: —

Leaves . . .	48 lbs.
Stems . . .	52 „

Leaves with 14 % of water, contain 29.2 % of albumin and the stems 16.2 %. 100 lbs. of lucerne hay, therefore, contain:

	Albumin.	
In the leaves . .	14 lbs.	
In the stems . .	8.4 „	(taking the average, somewhat less)
Total	22.4 lbs.	

From these data, it is clear that the relative as well as the absolute proportion of albumin in the leaves is considerably greater than in the stems.

If the produce per acre is assumed to be 8800 lbs. (80 cwt.), the amount of albumin produced will be: —

	Albumin.
In the leaves . .	1232 lbs.
In the stems . .	738 „
Total	1970 lbs.

If half of the leaves fall off during harvesting, that is represented by a loss of 616 lbs. of albumin of which about 308 lbs. (the half) is digestible. If one pound of digestible albumin is valued at 3 d., the loss per acre is nearly £ 4.

That the actual loss can be very great is shewn by *Weiske's* results. He obtained the following amounts of organic matter per acre: —

	Lucerne either green or dried without loss of leaf.	Lucerne dried by the ordinary method.	Loss.
Albumin	594 lbs.	441 lbs.	153 lbs.
Fat	105 „	55 „	50 „
Fibre	873 „	814 „	59 „
Non-nitrogenous extractives	1082 „	909 „	173 „

Drying by the ordinary method produced, in this case, a loss per acre of 153 lbs. of albumin, 50 lbs. of fat, 59 lbs. of fibre and 174 lbs. of non-nitrogenous extractives. The superior digestibility of properly dried hay is another factor which enters into such calculation.

Rain falling on the hay causes losses and still further diminishes the value. *Kellner* examined two lots of hay; the one was very carefully dried, the other lay in the open air for four and a half days and during this time a thunder-storm occurred and a light shower of rain fell. The exposed lot gave 7.13 % less hay than the other.

Analysis of both lots gave the following results: —

	Lucerne carefully dried.		Lucerne exposed to the rain.	
	Total amount.	Portion digestible.	Total amount.	Portion digestible.
Albumin	17.0 %	12.2 %	14.9 %	9.9 %
Fibre	31.8 %	15.3 %	34.0 %	15.4 %
Fat and Non-nitrogenous extractives	43.8 %	29.1 %	44.2 %	27.4 %
Ash	7.4 %	2.2 %	6.9 %	1.6 %
Dry substance . . .	100.0 %	58.8 %	100.0 %	54.3 %

Depasturing.

Lucerne does not stand depasturing; sheep are specially injurious because they eat away the young buds which, if not destroyed, would soon develope into new branches.

Yield.

Häni estimates the yield of hay obtained in Switzerland from four or five mowings at amounts varying between 3080 and 3520 lbs. per acre = 28 to 32 cwt. *Guido Krafft* states that the average yield of hay under favorable conditions varies between 5280 and 8800 lbs. = 48 to 80 cwt., but, that, during the second and third years, from 10560 to 11440 lbs. = 96 to 104 cwt. are obtained. *Werner* reckons that an excellent soil should give from 7920 to 10560 lbs. = 72 to 96 cwt., a good soil from 5280 to 7040 lbs. = 48 to 64 cwt., and a poor soil from 4400 to 5280 lbs. = 40 to 48 cwt. Calculated from these data, the average yield of hay is 7040 lbs. = 64 cwt. per acre. *Sprengel* reckons that 10560 lbs. = 96 cwt. are obtained from a good soil. *Schwerz* remarks that, in Germany, lucerne gives as much produce in three cuttings as red clover gives in two; but, in France, seven cuttings produce from 14960 to 15840 lbs. = 136 to 144 cwt.

Nutritive value.

According to *Wolff*, the composition of hay (containing 14 % water) and of green lucerne (containing 81 % of water when young, and 74 % before flowering) is.

Quality	Organic matter %	Albumin %	Fat %	Fibre %	Non-nitrogenous extractives %	Portion digested			Ratio of nitrogenous to non-nitrogenous nutriment
						Albumin %	Fibre %	Carbohydrates %	
Hay of average quality . . .	79.6	14.8	2.6	33.7	28.5	9.6	1.0	29.1	1 : 3.3
Hay of very good quality . .	79.0	16.0	2.6	27.4	33.6	12.7	1.0	32.4	1 : 2.8
Green fodder, quite young . .	17.3	4.5	0.6	5.0	7.2	3.5	0.3	7.3	1 : 2.3
Green fodder, before flowering	24.0	4.5	0.8	9.5	9.2	3.2	0.3	9.1	1 : 3.1

From this, it is plain that green lucerne is an excellent food-stuff, very rich in albumin; it is even more nutritive than red clover of medium quality. When green, it forms excellent food for milking cattle. For this purpose, it should be cut before it gets too old; if not, it becomes hard and then adds rather to the flesh than to the milk. As it is rich in albumin, food-stuffs poor in this respect can be mixed with it, for example, chaffed straw, green maize, etc. Cattle fed on such mixtures are not so liable to flatulence, a result frequently following the use of very young lucerne; but in general, lucerne is less liable to cause flatulence than red clover. Its hay is relished by horses as well as by sheep.

Harvesting the seed.

Harvesting, impurities and adulterations of the seed. Old fields soon to be broken up are selected for the seed-crop, because plants cut when in seed, are much exhausted and to some extent perish. In southern countries, seed is taken from the second cutting; in Germany, often from the first. The seed is ripe, when the pod (fig. 60) has become spirally twisted and dark in colour; at this stage, the seeds are yellow and of a cheesy consistence. The seed-crop is harvested in the same way as that of red clover. In the field, the seeds are not liable to fall out of the pods; they are, however, more easily removed by threshing than those of red clover. In the south, it is customary to thresh the seed plants immediately after cutting.

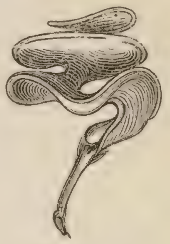
Fig. 60.
Lucerne.
Medicago sativa, L.
Legume × 4.

Yield of seed.

The produce of seed per acre, according to *Sprengel*, varies between 530 and 700 lbs. According to *Langethal*, between 350 and 530 lbs., and according to *Krafft*, between 300 and 490 lbs.

Purchase of seed.

In Switzerland and northern countries, a seed crop is not profitable; is is better to procure the seed from the south. The best, having the largest seeds and the highest germinating power, comes from Provence. The seed of Poitou, of Italy and of Hungary is not so good. During the first years, Italian lucerne is as good as that of Provence, but it is less lasting.

Impurities.

A common impurity is dodder *(Cuscuta trifolii*, Bab., fig. 61); the seed ought, therefore, always to be cleaned, to free it from this parasite. An excellent machine for the purpose is sold by *Egli & Co.* of Gibswil in the canton of Zurich; with this machine, dodder is removed and the loss of lucerne seed is very slight. Metallic seves of $^3/_4$ mm. mesh do not clean the seed so well, and the loss of lucerne seed is greater. When seed is purchased, the seedsman should be required to guarantee it free from dodder; a sample weighing about half a pound is necessary for analysis. Nothing is more vexing than to find dodder breaking out when, by careful attention to purchase of seed, this outbreak could easily have been avoided. Two impurities are very common in French seed, viz. *Centaurea*

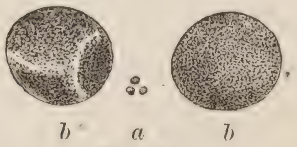

Fig. 61.
Dodder.
Cuscuta trifolii, Bab.
(C. epithymum, Murr.)
a. The end, natural size.
b. The same, × 12 to 15.

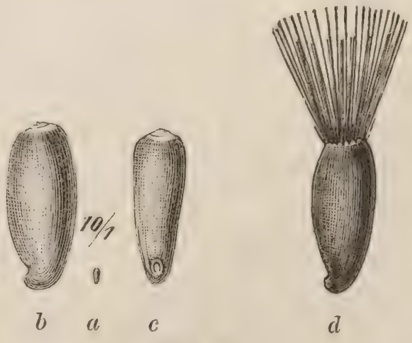

Fig. 62.
Yellow centaurea.
Centauria solstitialis, L.
a. The fruit without the pappus, natural size.
b and *c.* The same × 10.
d. The fruit with the pappus × 10.

solstitialis, L. (fig. 62) and *Helminthia echioides*, Gærtn. (fig. 63). The former is black, tapered towards the base, and usually without the pappus; the latter never has the pappus, is yellowish brown or orange, transversely striated, and either straight or bent.

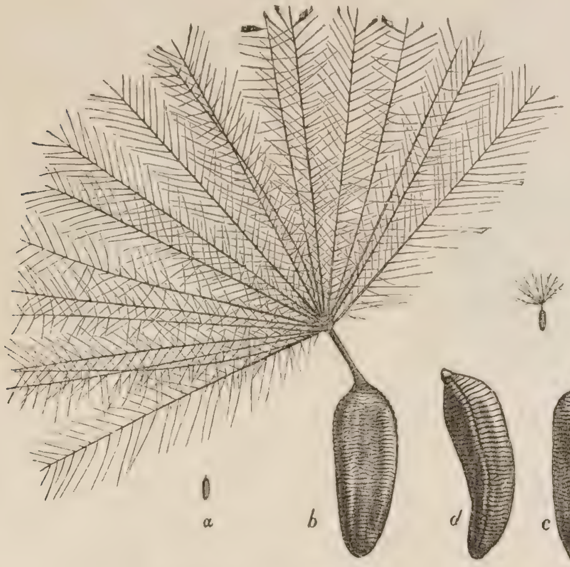

Fig. 63. (After Nobbe.)
Helminthia.
Helminthia echioides, Gærtn.
a. Fruit of a disc floret natural size. *b.* Fruit of a ray floret with the pappus × 7. *c.* The same as *a* × 7. *d.* The same as *b.* but without the pappus × 7. *e.* Fruit with pappus, natural size.

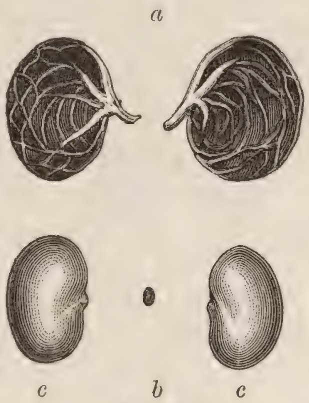

Fig. 64.
Trefoil.
Medicago lupulina, L.
a. The pod seated in the calyx, × 7.
b. The seed, natural size.
c. The seed, × 7.

Adulterations.

Adulteration is rarely attempted. Trefoil (*Medicago lupulina* L.) is often found mixed with lucerne; the seed (fig. 64) is smaller, roundish ovate, greenish-yellow and shining; it is at once recognised by the projecting tip of the radicle. Lucerne seed is more reniform, larger, somewhat angular from the mutual pressure of the seeds in the pod, flatter, and coloured yellow like the yolk of an egg. Seed from southern France is not shining and the yellow is of a deeper tint. Attempts at adulteration with seeds of *Melilotus* are rare and at once detected by the odour of coumarine and the dull colour; they are not reniform and the radicle is very distinctly marked off from the cotyledons. Melilot pods are sometimes present. Seeds of *Medicago maculata* and *Medicago denticulata* which come from South America are sometimes used as adulterants. The pods from which these seeds are obtained are covered with hook-like or scissor-like bristles which become entangled in the wool of sheep (figs. 66 and 67). Wool containing these pods is imported into Europe; ultimately, the seeds are obtained as a by-product of the wool. Closely resembling as they do the seeds of lucerne, they are either mixed with genuine lucerne or sold separately as lucerne, Chili lucerne, Buenos-Ayres lucerne, etc. The plants grown from such seed are annual with stems lying on the ground and of no agricultural value whatever. The seeds are larger, quite dull, and distinctly kidney-shaped; by these characters, they may be distinguished from genuine seed. The seeds of *M. maculata* are readily known by the projecting, often red tinted apex of the radicle. Small bent steel rods (fig. 70) — the fragments of the carding-combs used in preparing the wool — are also distinctive.

Seed quality.

Seed and amounts to be sown. The average purity is 97.2 % and the germination 89 %. Good average seed should have 98 % purity and 90 % germination = 88.2 % of pure and germinating seed. The above percentages of germination include one half of the hard seeds. The percentage of hard seed is often very high especially when the seed is recent, but diminishes with age. It follows that seed a year old is usually better than when recently cropped, and when two or three years old, it can be sown with the greatest freedom if originally good. Seed of good quality ought to be yellow and neither brown nor at all shrivelled. One bushel weighs from 61 to 63 lbs. One pound of pure seed contains from 182,000 to 237,000 grains. Seed from Provence is that which has the largest grains.

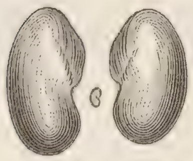

Fig. 65.
Lucerne.
Medicago sativa, L.
The seed, natural size, and × 7.

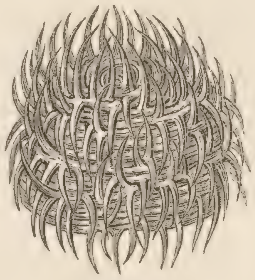

Fig. 66.
Spotted medick.
Medicago maculata, Willd.
The legume × 4.

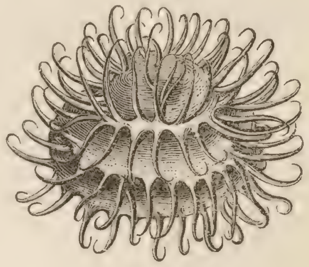

Fig. 67.
Medicago denticulata, Willd.
The legume × 4.

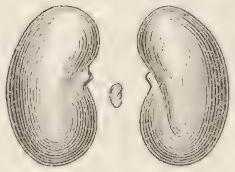

Fig. 68.
Spotted medick.
Medicago maculata, Willd.
The seed, natural size, and × 7.

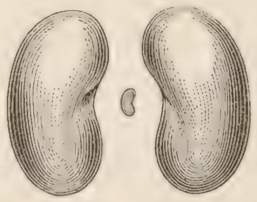

Fig. 69.
Medicago denticulata, Willd.
The seed, natural size, and × 7.

Fig. 70.
Portions of steel wire out of the seeds, natural size.

Amount to be sown.

On an average, an acre requires 25 lbs. of seed containing 88 % pure and germinating = 22 lbs. of pure and germinating seed. The amount to be used however, varies with the soil, situation, climate and manure.

Preparatory crop.

If the climate is unfavourable, the soil poor and over or under medium stiffness, the amount should be increased. Thick sowing is advisable for several reasons: — the plants are not so liable to be laid, the fodder is better because the stems are less lignified, and weeds are kept under.

Whether a field of lucerne is good or not depends largely upon the previous crop and, above all, on careful preparation of the land to be sown, for this plant is never successful unless the soil is friable and free from weeds, and the subsoil loose. The best preparation is, therefore, a root crop, such a potatoes, turnips, etc. Lucerne may succeed a rye-crop cut green, but, in this case, the preparation of the ground requires considerable labour.

Preparation of the soil.

After harvesting the preparatory crop, the ground is prepared as thoroughly and as deeply a possible. The subsoil-plough may be used, or two ploughs can be passed through the same furrow, the one to turn the surface soil and the other to stir the subsoil. This preparation of the subsoil is very essential, if the land is at all firm.

Time of sowing.

Lucerne is usually sown about the end of April or the beginning of May, when there is no danger of late frost which acts injuriously upon the young plants. Late sowing also has its risks, as the fly which comes in with the warm weather is equally injurious. If these insects are not dreaded. sowing may be delayed till the weather becomes favourable. In suitable climates, seed may be sown as late as the beginning of September. Late sowings are not so certain, because the plants are liable to be injured during winter.

Protective crop.

Lucerne is sown either with or without a protective crop. In Switzerland, the custom is to sow without a protective crop, since lucerne grows quickly and soon covers the ground with vegetation. During dry seasons and on dry situations, a protective crop is advisable. We may use, for this purpose, summer crops, such as barley or wheat which are sown very thin; even when protected, lucerne often suffers and readily becomes thin. Flax, camelina, etc., or a crop to be cut green, such as oats or buckwheat, are also suitable protective crops; the last is especially good, because by it the fly is kept off.

Sowing.

The seed is usually sown broad-cast and the clover sowing machine is excellent for the purpose. In England and elsewhere sowing in drills is often adopted as it renders weeding easier.

Preparation after sowing.

On stiff soils, the seed is only rolled in; for this purpose, disc rollers or Cambridge rollers are preferable to smooth, because, after disc rolling, the land is not so ready to form a hard crust on the surface; a light harrow is passed over light soils.

Succeeding crop.

Cereals, beetroot, and colza succeed well after lucerne; as cereals are very liable to be laid, the two latter are to be preferred.

Mixtures.

The addition of a small proportion of red clover to lucerne has been recommended, in order to obtain a good crop in the first year. This practice ought not to be followed, because red clover interferes with the growth of lucerne; the result is that, after two or three years, when the clover is gone, the lucerne is thin and defective. If the ley is not to extend over two or three years, then, of course, clover might be added; but if the ley is of longer duration, the clover is not advisable. As a general rule, pure sowings are preferable to mixtures, because, as soon as the ground is covered with any other vegetation, lucerne is interfered with. Only on soils most suitable for lucerne-growing can a mixture be used and then only on condition that cutting takes place at least three times a year to prevent hardening. Under fruit trees, lucerne should never be grown, for its deep roots are liable to injure those of the trees.

Injurious plants and insects.

Grass is the greatest enemy of lucerne. It covers the ground with a compact vegetation which chokes out the lucerne. The worst species are fiorin *(Agrostis stolonifera)*, common bent *(Agrostis vulgaris)*, rough-stalked meadow grass *(Poa trivialis)*, soft brome *(Bromus mollis)*, field brome *(Bromus arvensis)*, Yorkshire fog *(Holcus lanatus)*, etc. These grasses may be somewhat checked by harrowing in spring, as soon as the land is dry. As lucerne shoots about the end of April, the harrow should be used before that time. If dodder breaks out, repeated weeding may do some good. Lucerne is also liable to attacks from microscopic fungi as well as from nematode worms, such as the *tylenchus* of lucerne *(Tylenchus Havensteinii*, Jul. Kühn). In the south, it often suffers from the ravages of the insect larva *Eumolpus vitis*. In districts where these insects are very troublesome, it is advisable to stop the cultivation of lucerne for ten years or longer and grow other fodder plants, such as sainfoin, goat's-rue, mixtures, etc., which are not attacked by fly.

XXVIII. Trefoil.

Medicago lupulina, L.

Explanation of plate.

Fig. A. The flower bearing stems, natural size.
„ 1. The flower, side-view.
„ 2. The same, with calyx removed.
„ 3. The same, with calyx and standard removed.
„ 4. The keel, and sexual organs.
„ 5. The sexual organs.
„ 6. The pistil.
„ 7. The pod and persistent calyx.
„ 8. The seed, from the broad side.
„ 9. The seed, shewing the hilum.

Botanical description.

Botanical description. The tap-root produces few branches, and descends vertically to a depth of about one foot. The stem branches, which build up the plant, spring from the crown of the root (basal branches), and extend horizontally for some distance before bending up into the air; this mode of growth gives the plant a very diffuse and spreading character.

The *stems* are partly horizontal and partly ascending, branched, somewhat angular, covered with adpressed hairs, and from four inches to two feet in length. The *leaves* are alternate, compound, and trifoliate. The radical leaves have longer petioles than the cauline. The *leaflets* are obovate, wedge-shaped (cuneate) at the base, toothed (denticulate) at the apex and petiolate; the partial petiole of the medium leaflet is longest. The *stipules* are lanceolate, often toothed (Fig. A.).

The *inflorescence* is, at first, a spherical head which later becomes somewhat elongated and spike-like. The *peduncle* is axillary and much longer than the leaf. The *flowers* are very small — at most 3 mm. long. The *calyx* (fig. 1) is half as long as the corolla, but longer than it is in the variety *parviflora,* Döll.; the tube is pubescent, and deeply split superiorly; the teeth are five in number, and lanceolate. The *standard* (figs. 1 and 2) has a broad claw which, at the base, is slightly coherent both with the wings and the keel; the limb is broad, curved upwards, and completely envelopes the other petals. The *wings* are small, and have narrow claws; the *keel* is somewhat similar in structure.

Wings and keel together cover the lower part of the sexual organs, while the anthers and stigma lie exposed beneath the standard. Nine of the stamen filaments unite together to form a narrow trough, embracing the lower edge (dorsal suture) of the ovary (fig. 5); the free stamen is only half as long as the others (figs. 3 to 5).

Compared with the other parts of the flower, the *pistil* (figs. 3 and 6) is relatively large; the ovary is compressed and its lower surface hairy, the style short and curved upwards, the stigma capitate and placed at a short distance above the anthers.

Little or nothing is known concerning the relations between these flowers and insects. *Müller* noticed bees, flies, and butterflies visiting the flowers. *Darwin* observed, further, that plants covered with a net to prevent the visits of insects were much less fertile than others to which the insects had free access.

The variety *parviflora* is probably merely a female form of the plant, and, in that case, trefoil is an example of *gynodioicism.*

The *fruit* (fig. 7) is a pod, which is black, one-seeded, compressed, reniform and seated in the persistent calyx; the apex is curved; the surface is glabrous — except in the var. Wildenowii which has glandular hairs — and has projecting ribs which are concentric and reticulate.

The *seed* (figs, 8 and 9) is yellowish-brown, shining, compressed at the sides, and elliptical. The hilum is round, and lies on one of the narrow faces; immediately above it, the tip of the radicle forms a slight projection.

Distinction from yellow clover.

Trefoil is often confounded with yellow clover properly so called *(Trifolium filiforme,* L.). Distinction is easy: in the former, the corolla falls away after flowering, and the pod is laid bare; in the latter, the corolla is persistent and its withered remains envelope the pod. Further, the pods of yellow clover are smaller and not curved at the apex like those of trefoil.

Name.

This plant has received many names such as hop-trefoil, yellow trefoil, yellow clover, hop clover, black medick, nonsuch, etc. In France, it is called »*Minette*«.

History.

Judtmann remarks that hop trefoil was not grown in Germany in 1790, although in England it had proved successful, and was in common cultivation at that date. *Hartlib* states that it came into cultivation in England about 1659. The cheapness of the seed rather than the good qualities of the plant has, according to *Lawson,* brought this trefoil into common cultivation in England.

Agricultural value.

Although neither very productive nor persistent, still, on many soils where red clover is not successful, this plant becomes valuable because its fodder is so nutritive. For calcareous land incapable of bearing clover it is specially suitable. It is an excellent plant in pastures. Because of the diffuse and spreading habit of its stems, hop trefoil is usually sown in mixture with clovers and grasses, and then forms excellent pasturage for sheep and cattle. It is less suitable in mixtures for hay production. In any case, as the plant itself only lasts for one or two years, it ought only to be used in leys of short duration. In mixtures on warm and favourable soils, it reaches maturity, and propagates by sowing its own seed.

Geographical distribution.

Occurrence, climate, soil, manure. Trefoil is indigenous throughout *Europe,* except in northern Norway, Lapland, the greater part of Finnland, and northern Russia. It is also indigenous to northern *Africa:* and to temperate *Asia,* in Caucasus, Georgia, Armenia, and Siberia (Ural, Altai, Baikal).

Habitat.

It is found, in greatest abundance, on moist calcareous fields, meadows, pastures, and wood-clearings.

Limits of altitude.

In the alpine regions, it occurs at high altitudes: for example, in the upper Engadine at Pontresina and Celerina at 6000 feet and on the Bavarian Alps at 4300 feet.

Climate.

Hop trefoil resists cold better than red clover. Although it withstands drought well, it loves a moist and warm climate; in England, therefore, the produce is greater than in the dry climates of the continent. In warm situations the duration is also longer.

Soil.

Any soil, if not too poor and containing sufficient moisture and lime, is suitable, except such as are very wet or sour. It thrives tolerably well even on sands, not too dry and on moorlands, if they are well-manured and contain lime. It is most successful on clay marls. It requires little from the subsoil, but the surface layers must be suitable. As already pointed out, the cultivation of trefoil should only be undertaken where the better kinds of clover cannot be grown.

Substances removed from the soil.

According to *Anderson & Marchand,* 100 lbs. of hay remove from the soil: —

Phosphoric acid . .	4.6 lbs.	Lime	15.4 lbs.
Potash	17.3 ,,	Sulphuric acid . .	2.2 ,,
Soda	4.5 ,,	Silica	1.9 ,,
Magnesia	4.7 ,,		

According to *Wolff,* the amount of Nitrogen is 2.4% = 24.2 per thousand. It is thus seen, that trefoil makes somewhat large demands upon the soil, and as the root system is not deep-seated, mainly upon the superficial layers.

Manure.

It is better to allow trefoil to follow a well manured crop than to add fresh manure. It has been asserted, that it does not thrive with fresh manure. It is certainly the case, that the stems of trefoil — spreading as they do, along the ground — may easily become impregnated with manure, and taste of it; then, of course, browsing animals do not readily eat it.

Marling and liming are advantageous when the soil is poor in lime. Gypsum also furthers the development of trefoil, and, on land to which ashes or artificial manures have been applied, a great deal of trefoil crops up where previously none was noticed, a certain sign that such manures are favourable to its growth. On poorly manured land, the plant is dwarfed, growing only one or two inches high, but as soon as artificial manures are added, more especially those containing potash and phosphoric acid, it becomes quite large and many times its former size. Irrigation is not suitable for this plant.

Growth.

Growth, yield, nutritive value. Trefoil spreads its stems along the ground almost to a distance of two feet. However, if the plants are thickly sown, or more especially mixed with others of erect growth, the diffuse character becomes less marked. In any case, the stems are always more or less spreading; accordingly, as development goes on, they interlace, and the ground is thus completely covered. The stems are soft and succulent; the leaves, numerous and small.

Development.

Development is so rapid that trefoil, sown in spring, yields its principal produce during the same year. In the second year, the plant usually dies after the first cutting. It shoots as early in spring as lucerne, and, in a warm situation, comes into flower at the end of May — ten to fourteen days earlier than red clover. Although the plant developes new stems and flowers, after the first cutting, the second is rarely as productive as the first. Trefoil is difficult to mow, and a great deal of the produce escapes the scythe, because of the spreading habit of the stems. For these reasons, it is more suitable for pasture than for hay. It stands depasturing better than either red clover or lucerne, and its use for this purpose can commence early in spring.

Yield.

According to *Werner*, the average produce of hay per acre, from a light sandy soil, varies between 1760 and 2640 lbs. = 16 and 24 cwt.; from soils of a better class, 3500 lbs. = 32 cwt. are obtained.

Nutritive value.

100 lbs. of the fodder contain:	Hay.			Green.		
Water	14.0			80.0		
Organic matter	79.8			18.5		
Albumin	15.1	portion digested	9.4 %	3.5	portion digested	2.2 %
Fat	3.4	,, ,,	2.1 %	0.8	,, ,,	0.5 %
Fibre	27.1	,, ,,	37.6 %	6.0	,, ,,	8.7 %
Non-nitrogenous extractives	34.2			8.2		
Ratio of nitrogenous to non-nitrogenous nutriment	1 : 4.5			1 : 4.6		

It is clear from this analysis, that trefoil hay contains more nutritive matter than red clover hay of medium quality. The stems do not become hard, and, therefore, the hay is readily eaten, although it is somewhat bitter. *Giersberg* states that butter made from the milk of animals fed on trefoil has a nut-like taste, and a beautiful yellow colour.

Harvesting the seed.

Harvesting, impurities and adulteration of seed. Trefoil produces abundance of seed. If it has been sown in spring with a summer cereal, the seed-crop can be taken in autumn. The first seeds are already ripe when the apical spikes are only coming into flower. It is thus impossible to obtain seed from all the flowers; in addition, a good deal is lost because the pods easily fall off. The plants are cut when the greater number of seeds are ripe, as indicated by the black colour of the pods. If the first cutting is used for seed, the crop is mown about the end of June or the beginning of July. Many precautions are necessary to minimise loss of seed.

The pods are easily threshed off; a common practise is to do this by simply beating the plants, spread out on cloths, with the fork. It is more difficult to remove the seeds from the tough pods (fig. 7). The clover shelling machine is most suitable for this purpose. Other methods, such as those described under red clover, may be adopted. During shelling, very many seeds become crushed and broken; the percentage of these in commercial seed frequently rises to 10, 20, or even more.

Yield of seed.

The yield of seed per acre, according to *Werner*, varies between 440 and 700 lbs.

Impurities and adulterations.

Wild mustard or charlock *(Sinapis arvensis)* and ribgrass *(Plantago lanceolata)* are frequent impurities. Adulteration is not attempted, because the seed is so cheap. But for this reason *viz.* the cheapness of the seeds, hop trefoil is often mixed with other seeds, such as red clover and lucerne (which see).

Seed quality.

Seed and amounts to be sown. Good commercial seed should have 97 % purity and 85 % germination = 82.5 % of pure and germinating seed. One lb. of pure seed contains, on an average, 328,000 grains. The bushel varies in weight from 64 to 66 lbs.

Amounts to be sown.

One acre requires 18 lbs. of seed, containing 82.5 % pure and germinating = 14¾ lbs. of pure and germinating seed. When the seed used for sowing is unshelled, twice as much is needed.

Sowing.

The clover sowing machine is suitable for sowing trefoil. The preparatory crop, preparation before sowing, and after culture, are the same as for lucerne (which see), a protective crop may or may not be used.

Mixtures.

Trefoil should never be sown pure, and, in mixtures of grasses and clovers, its only use is to form bottom herbage. Its short duration fits it for clover grass mixtures to be used for two years. A good pasture mixture for a sandy soil is white clover 65 per cent, trefoil 35 per cent. If the ground is more suitable for trefoil, its proportion in the mixture may be increased, while that of white clover is diminished. Mixtures with red clovers and Italian rye-grass are also used. In mixtures for hay, it is less appropriate, because the deep shade, which is cast by its half creeping half ascending stems, may easily lead to loss of other plants better than itself. On good soils, all plants with spreading habit of growth should, for a similar reason, be kept out of hay mixtures whether for temporary or permanent leys.

XXIX. Bird's foot trefoil.

Lotus corniculatus, L.

Explanation of plate.

Fig. A. Two stems, shewing flower and fruit.
,, B. Base of a leaf, shewing rudimentary stipules.
,, C. Leaf of *Lotus tenuifolius.*
,, 1. The flower, front-view.
,, 2. The same, side-view.
,, 3. The same, with calyx removed.

Fig. 4. The same, with calyx and standard removed.
„ 5. The keel and reproductive organs, side-view.
„ 6. The same, viewed from above.
„ 7. The same as figure 5 with one side of the keel removed.
„ 8. The reproductive organs of a flower bud (after Müller).
„ 9. The reproductive organs and apex of keel in a mature flower (after Müller).
„ 9a. The pistil.
„ 10. The nine coherent stamens, spread out.
„ 11. The legume, before opening, natural size.
„ 11a. The same, magnified.
„ 12. The same, after dehiscence.
„ 13. The seed, from the broad surface.
„ 14. The seed, shewing the hilum.

Botanical description.

Botanical description. The *tap root* descends vertically into the ground and is spindle-shaped (fusiform). It is crowned by a simple, short and thick stock from which all the branches are produced. At their origin, they are quite close to one another, and either ascend directly into the air, or spread somewhat along the ground but never strike root nor form stolons. The short stock which crowns the root always remains simple, and from it, alone, branches are produced.

The *stems*, thus produced, vary in length from 6 to 18 inches, are angular, spreading, or ascending, and hairy or glabrous according to the variety.

The *leaves* are alternate, compound, composed of five leaflets, and the petiole is very short. The *leaflets* themselves are obovate and wedge-shaped at the base or lanceolate and acute, and either glabrous or hairy; the upper surface is dark green and the under glaucous. A long stretch of midrib separates the three terminal leaflets from the basal pair (fig. A). The *stipules* are quite rudimentary and reduced to bristles or glands (fig. B); the lowest pair of leaflets is often regarded as stipules, because of their position, which is almost basal, but we, with *Acherson*, prefer to regard them as leaflets.

The *flowers* have short pedicels and occur in groups forming small umbels composed of from two to six flowers. The peduncle is axillary and longer than the leaf. A trifoliate *bract* is situated at the base of the umbel, and forms a kind of involucre.

The *calyx* (fig. 2) is gamosepalous, and either glabrous or short haired, according to the variety; the tube has five well marked veins which run out into the teeth, and numerous others, less strongly marked, between; the teeth are five in number, acute, and connivent before flowering.

The *corolla* is golden yellow, except the standard, which has a tinge of red before and often even after flowering, and when withering, gradually becomes bluish green.

The *standard* (fig. 3) has a narrow claw and a vertical limb convex in front. The *wings* (fig. 1) have also a narrow claw, and the limb is very convex and swollen; when the flower is viewed from the front, so that both limbs are seen together, they form a hemisphere, so great is the convexity. The *keel* (fig. 5) is prolonged anteriorly into a conical beak, which contains the sexual organs (figs. 5, 7 and 9). Nine of the ten *stamens* cohere by their filaments so as to form a tube split superiorly and surrounding the pistil; the free stamen fills up the slit in the tube, and right and left at its base is a small aperture leading to the honey within the tube (fig. 6).

Hermann Müller has shown that, in the flower bud (fig. 8), the free parts of the stamens are equal in length, and also that, at an early period, the anthers shed their pollen in the beak of the keel and then wither; while the flower is opening, the filaments of the five exterior stamens lengthen, and become club-shaped, so as to form a plug beneath the pollen contained in the beak (fig. 9).

The *pistil* is composed of: a long many-ovuled ovary, which is cylindrical, and convex on the upper edge; a stiff, bristle like, terminal style forming an obtuse angle with the ovary; and a terminal stigma, lying in the beak distinctly above the anthers (fig. 7).

Hermann Müller draws attention to the following points in connection with the visits of insects to the flowers. When the insect alights upon the wings, the pressure lowers both wings and keel; then the plug, formed by the swollen ends of the stamens, acts, in the keel, like the piston in a pump, the pollen is poured out from the apex of the beak, and becomes attached to the ventral surface of the insect. When the keel is lowered still further, the stigma itself is protruded and strikes against the ventral surface of the insect guest. It is clear, that, in this way, the stigma may receive either the pollen from a flower previously visited, or its own. No experiments have been made to show how the amount of seed produced is affected when the visits of insects are prevented.

The *fruit* (fig. 11) is a cylindrical pod (legume), about an inch or more in length, and one-tenth of an inch in breadth; the surface is brown, wrinkled and netted; numerous seeds are contained in each pod, and, between the seeds, the walls of the pod form cellular ingrowths. When ripe, the legume dehisces by two valves which are spirally twisted (fig. 12). The *seeds* are oval, slightly flattened at the sides, brown, shining (fig. 13 and 14); the length varies between 1 and 1.25 mm.; the hilum is a white, round spot, situated in a small depression on one of the narrow surfaces of the seed. This description applies to the seeds of the var. *tenuifolius*, but those of *L. uliginosus*, are much smaller (from 0.75 to 1 mm. long), and olive green in colour.

Varieties.

Varieties. Three varieties are of importance in agriculture. 1. Common bird's-foot trefoil (*Lotus corniculatus* var. *vulgaris*) is the variety figured in our plate, and described above. 2. Slender or fine-leaved bird's-foot trefoil (*Lotus corniculatus* var. *tenuifolius*) is as large or even larger than the preceding, and is distinguished by the narrower leaves and stipules, which are either lanceolate or linear (fig. C). This variety is sometimes reckoned as a distinct species, and then goes under the name of *Lotus tenuis*, Kitaibel. It is frequently met with on land containing salt and is very valuable for cultivation on soils of this nature. Commercial seed, offered as »large-seeded bird's-foot trefoil« usually belongs to this variety. 3. Hairy bird's-foot trefoil (*Lotus corniculatus* var. *villosus*) has the character implied by its name and is more erect than the var. *vulgaris*, but, in other respects, they agree. It is found more especially on newly broken up heath-lands.

In commerce the seed called »*Lotus villosus*« is usually found to be that of marsh bird's-foot trefoil (*Lotus uliginosus*, Schkuhr). All gradations between these three varieties are found.

Name.

This pretty plant with its intensively coloured yellow flowers, often with a play of red and green, has long attracted attention and has received very many popular names, e. g. bird's-foot clover, butter-jugs, shoes and stockings, ladies' slipper, cross-toes, cheesecake grass, etc.

History.

Two centuries ago, the excellence of this plant was recognised in England by *Worlidge*, who — in his »Mystery of Husbandry« 1681 — classes it with perennial rye-grass, sainfoin, lucerne, clover, vetches and spurrey. Although the plant is so common, the actual date, at which its cultivation commenced in Britain, is uncertain; *Schwerz* first brought it under the notice of German agriculturists and pointed out its importance.

Agricultural value.

By itself, bird's-foot trefoil is not productive, but it is very suitable, in mixture with fodder plants of taller growth, for filling up the spaces beneath and between them; in this way, it materially adds to the produce. It is suitable either for cutting, or depasturing. It thrives almost on any soil, and is perennial. These properties render bird's-foot trefoil a very valuable plant for permanent pastures and meadows. It is also appropriate for shorter leys, where red clover does not thrive. The great obstacle to its cultivation is the very high price of the seed.

Geographical distribution.

Occurrence, climate, soil, manure. The variety *vulgaris* is very common. It is indigenous to *Europe*, except Lapland and northern Russia; in southern climates it is almost entirely confined to the mountainous or Alpine regions. It is also indigenous: to northern *Africa* (Barbary, Egypt, Abyssinia) and to *Asia* (Caucasus, throughout Asia minor, Ural, Altai, Japan). It has been introduced into Australia and is wanting in North America.

The fine-leaved variety, *tenuifolius*, is found throughout Europe, except Norway, the greater part of Sweden, Finland, Northern and Central Russia, Spain and Portugal. It is not found in Asia, Africa or America.

Habitat.

It occurs in a wild state on roadsides, around woods and fields, and in meadows and pastures at high elevations.

Limits of altitude.

In the Swiss Alps, it ascends to 10,000 feet at Zermatt. Upper Engadine 5600 ft., Churwalden 6500 feet, Schwefelberg 4500 to 6000 feet, on the moraines of the Eiger Glacier 6500 feet; the Alpine forms, *alpestris* and *glacialis*, are met with between 6000 and 10,000 feet. In the Bavarian Alps, it is found at 6000 feet, in the Pyrennees at 9000 feet, in Spain at 10,800 feet, and in the Caucasus at 8000 feet.

Climate.

If the land has some fertility, bird's-foot trefoil can withstand the roughest climates and resist excessive drought, but, in either of these circumstances, the growth is stunted. The most suitable climates are those with a very moist atmosphere, where the wild plants abound, as mountains and sea-coasts.

Soil.

It thrives almost on any kind of soil, whether arid or humid, dry or moist, sandy or clayey, marly or calcareous, even on moors and land containing salt. Dry land at high elevations, though poor, suits it remarkably well, and, on such, it is more productive than any other leguminous plant.

Substances removed from the soil.

1000 lbs. of hay, according to the Swiss analyses, contain: —

Nitrogen 25.1 lbs., ash 79.4 lbs. composed of: —

Phosphoric Acid	10.9 lbs.	Lime	20.8 lbs.
Potash	23.3 ,,	Sulphuric Acid	2.4 ,,
Soda	0.9 ,,	Silica	7.3 ,,
Magnesia	5.2 ,,		

Manure.

Like trefoil, it loves a rich surface soil, although it requires less from it than from the subsoil. It possesses, in a very high degree, the power of converting dormant matter into available nutriment. On it, as on other trefoliate leguminous plants, gypsum exercises very favourable influence.

Growth.

Growth, yield, nutritive value. The stems of this plant are hard, and, as in trefoil, their bases extend horizontally without rooting, along the surface of the ground, gradually ascend into the air, reaching a height varying between six inches and two feet. This spreading habit of growth, allows bird's-foot trefoil to cover the ground almost completely, but still gaps are left between the branches. If the plants are growing thickly, in mixture with other of erect habits, bird's-foot trefoil also becomes straight and tall. The fusiform tap-root penetrates the soil to a tolerable depth.

Development.

The plant is at its best, only in the second year of growth. In spring it shoots at the same time as red clover, and by the end of May, or the beginning of June, the flowering stage is reached. After the first cutting, the produce is not large, although the plant produces a new crop of flowering stems.

Harvesting.

Plants, cut when in full flower, contain the maximum amount of nutriment. The cut produce is either made into hay or fed off green (in mixtures). The herbage may also be depastured. When the fodder is to be used green, it is advisable to cut the plants before flowering, because the colouring matter, contained in the expanded flowers, is bitter, and very disagreeable to stock. For the same reason, when the plants are depastured, those which have been in flower for some time, are avoided by the cattle. When dried, the thick leaves, which are rich in nutriment, readily fall off; in hay making, therefore, the plants should be moved as little as possible.

Yield.

100 lbs. of green plant give, according to *Nickles*, 25 lbs. of hay, and according to *Sinclair*, 31 lbs. *Ritthausen* estimates that the green fodder contains 79.2 % of water. From a clay loam, *Sinclair* obtained, at the time of flowering, 3190 lbs. of hay per acre. This species is clearly not very productive, and it is, therefore, advisable to use it only for forming bottom herbage in mixtures.

Nutritive value.

100 lbs. of hay, harvested while in flower, on the southern slope of Zurichberg, contained (reckoning the water at 14 %) 77.9 % of organic matter, composed of: —

Nitrogenous matter (N × 6.25)	15.7 %
(Albuminoid N. 1.91 %, non-albuminoid N. 0.60 %)	
Fat	3.7 %
Fibre	22.0 %
Non-nitrogenous extractives	36.5 %

According to *Ritthausen*, the hay contains 79.4 % of organic matter composed of: — 13.3 % nitrogenous matter, 44.2 % of fat and non-nitrogenous extractives, and 21.9 % fibre.

The fodder is, therefore, very nutritive and, in this respect, surpasses red clover hay of medium quality. When cows are fed on it, the intense yellow colouring matter, contained in the flowers, gives a deep yellow colour to the milk and even to the butter produced from it.

Harvesting the seed.

Harvesting, impurities and adulteration of the seed. The first cutting is used as the seed-crop. It is ready for mowing about the end of July or the beginning of August. During harvesting, the pods readily dehisce, and allow the seeds to escape — an indication that cutting should take place before maturity, at a time when the pods are commencing to change colour, and become brown. If the pods are stripped off by hand in the field, they are allowed to become brown and spread out in an airy place till they become fully mature. They will then dehisce of their own accord. Although the ovary contains a number of ovules, only a small proportion of these develope into good seeds, hence the small quantity of seed produced and its high price — two to four shillings per lb.

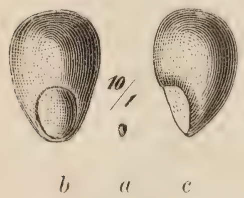

Fig. 71.
Germander.
Teucrium Chamædrys, L.
a. Nutlet, natural size.
b. The same, from the inner face, × 10.
c. The same, side-view, × 10.

Impurities and adulterations.

Charlock or wild mustard (*Sinapis arvensis*, L.) is a frequent impurity; this is darker in colour, more spherical and has the well known mustard taste: some consider that it is intentionally added, and then, of course, it is an adulterant.

The seed known in commerce as tall, hairy, or small-seeded bird's-foot trefoil *(Lotus villosus)* is very often marsh bird's-foot trefoil *(Lotus uliginosus*, Schk.) Plants produced from this seed have no agricultural value, except on marshy or moor-land. Its seed is only half the price of the other; the smaller size and beautiful olive green colour at once distinguish it. In commerce only the large, shining, brown seeds represent genuine *Lotus corniculatus*, and these, when grown, usually turn out to be the fine-leaved variety, viz. *Lotus corniculatus* var. *tenuifolius*. The two other principal varieties, *vulgaris* and *villosus*, appear to be rare in commerce judging from our trials of purchased seed. The seeds of the three varieties are indistinguishable. Under the name of *Lotus corniculatus*, I obtained, two years ago, a sample of seed which, after careful examination, turned out to be the germander *(Teucrium Chamædrys,* L.) The nutlet of this species has some resemblance to the seed of *Lotus,* but it is darker brown in colour, dull, and the base, which is slightly wedge-shaped and acute, has a large scar at the side; two of the lateral faces are flattened, in consequence of the mutual pressure exercised by the four nutlets, situated at the base of the persistent calyx (see fig. 71, pag. 163). More rarely, the nutlets are rounded; this happens when only two of the nutlets — instead of the four normally developed — are produced by a flower.

Seed quality.

Seed and amounts to be sown. Commercial seed has, on an average, 85 % purity and 50 % germination = 42.5 % of pure and germinating seed. In determining the germinating power, one-third (= 10 %) of the hard seeds (= 31 %) are reckoned as germinating. One lb. of pure seed contains 375,000 grains, while one lb. of marsh bird's-foot trefoil *(Lotus uliginosus)* seed contains 854,000. The weight per bushel is about 60 lbs.

Amount to be sown.

One acre requires 11 lbs. of seed, containing 42.5 % pure and germinating = 4.675 lbs. of pure and germinating seed.

Sowing.

In mixtures, it is customary to sow this plant in spring, rarely in autumn. The seed is very tardy in its germination. Concerning the preparatory crop, preparation of soil, depth of sowing, the reader is referred to the remarks under these heads in the article on lucerne. It is usually sown in a protective crop.

Mixtures.

The land is left in good condition, in consequence of the very complete shade which the plant affords. Bird's-foot trefoil, as already mentioned, is very rarely sown by itself. It occupies its proper place only, when used in mixtures to form bottom herbage on permanent hay-land: in such circumstances, it adds considerably to the produce. In addition, it has a very perennial character, and should, accordingly, always find a place in permanent hay mixtures.

Marsh bird's-foot trefoil.

Marsh bird's-foot trefoil *(Lotus uliginosus,* Schk.), whose seed occurs in commerce under the name of *Lotus villosus,* is a plant adapted for fodder production only on moor- or marsh-land; on other soils, it is smaller and later in development than ordinary bird's-foot trefoil.

XXX. Officinal goat's-rue.

Galega officinalis, L.

Explanation of plate.

Fig. A. Summit of the flower-bearing stem.
,, 1. The flower, side-view.
,, 2. The calyx, showing the tube and teeth.
,, 3. The flower, with the calyx and the standard removed, side-view.
,, 4. The wing.
,, 5. The keel and stamen-tube, side-view.
,, 6. The reproductive organs.
,, 7. The pistil.
,, 8. The legume, seen from the dorsal suture.
,, 9. The legume, side-view.
,, 10. The seed, seen from the hilum.
,, 11. The seed, side-view.

Botanical description.

Botanical description. The *tap root* — a direct prolongation of the first year's stem — is swollen and napiform, and descends to a considerable depth, in the soil. The lateral branches are originally buds in the axils of the radical leaves; they develope either in the first or second year into the lateral branches. Ascending vertically, they form a compact tuft.

The aerial *stems* are three to four feet in height, erect, cylindrical and hollow and much branched. The *leaves* (fig. A) are imparipinnate; the midrib has a groove on its upper surface, and bears from four to eight pairs of opposite leaflets. The *leaflets* of the radical leaves are rounded, those of the cauline, oblong-lanceolate with silvery hair on their margins, and terminated by a long mucro; the upper surface is dark green and dull; the lower, lighter in colour, shining and provided with sparse adpressed hair. The radical leaves may reach the length of a foot or more, and the base of the petiole is spread out to form a red coloured sheath. The *stipules* of the radical leaves are lanceolate and adnate to the petiole; those of the cauline, semi-sagittate with three acute teeth. In the bud, the leaflets are simply folded along the midrib.

The *inflorescence* (fig. A) is an axillary raceme of loosely arranged flowers with a peduncle longer than the leaf from whose axil it springs. The *bracts* are persistent almost till the fruit ripens, and awl-like; they cover up the young flowers and surpass them in length so much as to produce at the apex of the raceme a sort of tuft (fig. A).

The *flowers* are almost half an inch long, either light violet or quite white in colour, and even the violet flowers have the wings and keel almost white. The *calyx* (fig. 2) is gamosepalous and about one-fifth of an inch in length; the tube is conical and ten-ribbed; the teeth are five, as long as the tube, awl-shaped, and slightly downy.

The *standard* (fig. 1) has a short, broad claw enclosed in the calyx-tube; the limb, rounded, gradually tapered off into the claw, emarginate at the apex, keeled along the middle line, reflex at the margins, and ascending at a right angle to the calyx. The *wings* have narrow claws. From each *wing* (figs. 3 and 4) a process is given off, which extends backwards and inwards so as to overlap and press upon the keel; in front of this is a cavity, into which a corresponding outgrowth of the keel fits and locks the parts together, so that, when the wings are pressed down, the keel is carried along with them and when the pressure is removed, the parts return to their original position. The keel is composed of two petals (fig. 5) entirely coherent, except at the very base of the claws and at the other extremity, which forms the curved beak. The *stamens* (fig. 6) are ten in number; all the filaments unite to form a tube, complete for half its length; then the upper filament becomes free, and the tube is now split; the free ends of the filaments and the anthers lie in the beak of the keel.

The *pistil* (fig. 7) is composed of a long narrow ovary, a filiform style curved upwards, and a small capitate stigma wich protrudes beyond the anthers (fig. 6).

No observations have been published on the secretion of the nectar or the visits of insects.

The fruit (figs. 8 and 9) is dark-brown in colour, many-seeded, linear, almost cylindrical and slightly constricted (moniliform) between the seeds, its length varies between 15 and 37 mm. and its diameter, between 2 and $2^1/_2$ mm.; the ventral and dorsal sutures appear as fine longitudinal veins from which numerous and close striæ spring out and ascend at a very acute angle towards the apex of the pod; these striæ from each suture cross in the middle of the valve at an angle equally acute (fig. 9). Each legume contains from three to seven *seeds* (figs. 10 and 11), of a light greyish-brown colour, angular, reniform, 4 mm. long, 3 mm. broad and $1^1/_2$ mm. thick; the hilum is round and occupies the centre of a depression on the ventral surface of the seed.

Varieties.

Varieties. In gardens, two varieties are in cultivation for ornamental purposes, viz. 1) the white flowered, and 2) the red flowered goat's-rue. Both are of equal value in agriculture.

History.

In ancient times goat's-rue was well known as a medicinal plant (as a remedy against the plague, according to *Haller*). As a fodder plant, it was recommended in Germany by *Krause* in 1773, by *Moser* 1796, and later by others. At the present time, it is rarely cultivated.

Agricultural value.

Goat's-rue is an excellent fodder plant for warm sheltered situations, where the soil is deep, even though it is dry and poor. It soon dies, when shelter is insufficient and, for that reason, is has not been cultivated in Germany. It is, however, of great value and very persistent in the well sheltered valleys of Southern Switzerland, to which manure cannot easily be transported, *e. g.* at Valais, Grisons, and Tessin.

Geographical distribution.

Occurrence, climate, soil, manure. This plant is indigenous to South Eastern *Europe;* but whereas in olden times it was cultivated in central Europe for medicinal purpose, it has now become naturalised in Germany, France, Switzerland, etc.

Habitat.

When wild, it always frequents humous situations, under hedges, in bushes, wood-clearings, or meadows — wherever it finds protection against the cold.

Limits of altitude.

It never occurs wild on mountains, but confines itself to low-lying lands.

Climate.

It requires a sheltered situation, because, in severe winters, it may either be killed by the frost or uprooted. This may be partially prevented by covering it with unrotted manure, or potato tops. As its roots are deeply seated in the ground, it is little affected by drought.

Soil.

It thrives only in a deep soil, and when the subsoil is not wet; its requirements, in these respects, are similar to those of lucerne, but manuring is not so important. It can be cultivated even on scorching soils.

Substances removed from the soil.

According to the Swiss analyses, 1000 lbs. of hay remove from the soil: — Nitrogen 27.3 lbs., mineral matter 71.8 lbs. composed of:

Phosphoric acid	8.9 lbs.	Lime	14.3 lbs.
Potash	25.4 ,,	Sulphuric acid	3.4 ,,
Soda	2.0 ,,	Silica	8.9 ,,
Magnesia	2 8 lbs.		

Manure.

Under this head, it is important to notice that deep-rooted plants, such as goat's-rue, satisfy their requirements to a large extent from the subsoil, consequently, manure is of little importance.

Growth.

Growth, yield, nutritive value. According to the nature of the soil, the plant forms stems with abundant foliage, but varying between two and five feet in length, and when thinly planted, very many branches are developed, but when close, the number diminishes.

Development.

After each cutting, the buds at the base of the stems quickly open out and form a new set of stems. If sown in spring, one or two cuttings may be taken in the same year, as the plant is a rapid grower. On the experimental field at Zurich, goat's-rue was sown on May 4th 1882; it came into flower on July 21st, and two cuttings were easily taken in the same year. In spring, it shoots somewhat later than lucerne or sainfoin; in 1883, it flowered about the end of June, and, when cut, the yield was very abundant. After cutting, it grows more rapidly than sainfoin, but less quickly than lucerne, it yields two cuttings, and the produce of the second is almost as abundant as the first, because stems and flowers are reproduced in it. The second cutting should not be taken later than September, in order to allow the plants time to reestablish themselves and become better able to withstand the winter frost.

Harvesting.

Cutting should always take place, when the first racemes begin to flower, because, as the flowering advances, the stems become hard, and are then not eaten by stock. Until the flowering stage is reached, the plants are soft and full of sap. They are used green, because drying is very difficult, renders them hard, and leads to great loss of leaf. In warm situations, and where manuring is impracticable, the yield is as high as that of lucerne, especially if the plants are cultivated in rows which allow thorough hoeing.

Nutritive value.

In the green state and before flowering, goats's-rue is very readily eaten, and the nutritive value is high. 100 lbs. of hay containing 14 % of water contain: —

Organic matter 78.7 lbs., composed of:

Nitrogenous matter (N. × 6.25)	17.1 %
(albuminoid-nitrogen = 1.59 %, non-albuminoid nitrogen = 1.14 %.	
Fat	1.4 %
Fibre	34.1 %
Non-nitrogenous extractives	26.1 %

The dry plant thus contains 4.5 % more nitrogenous matter than clover hay of medium quality. The percentage of woody fibre is also higher, but the amount of fat and of non-nitrogenous extractives is lower. It follows that goat's-rue is a very nutritive fodder plant.

The produce of the first cutting after sowing, taken on August 4th 1882, from the same field, contained dry matter 78.2 % composed of: —

Albumin	10.5 %
(albuminoid-nitrogen 1.14 % non-albuminoid nitrogen 0.51 %)	
Fat	1.8 %
Fibre	35.3 %
Non-nitrogenous extractives	30.6 %

Harvesting the seed.

Harvesting, impurities and adulteration of the seed. Goat's-rue produces abundance of seed which is easy to harvest. It is true, that the seeds ripen somewhat unequally, but, as the pods are not liable to fall off, cutting can be delayed, till all the pods are ripe. When the plants are dried, the seeds are threshed out. Impurities are rare, and adulteration is not attempted.

Seed quality.

Seed and amounts to be sown. Good seed should have 98 % purity and 32 % germination*) = 31·4 % of pure and germinating seed. One lb. of pure seed contains 62,000 grains.

Amount to be sown.

An acre of ground requires 22 lbs. = 6.9 lbs. of pure and germinating seed. *Vilmorin, Andrieux & Co.* of Paris sell the seed at about 10 d. per lb., so that seed for an acre costs about 18 shillings.

Sowing.

The seed is sown in spring, preferably without a protective crop. Since the seeds are larger than those of lucerne, they can be sown somewhat deeper. The plant is always grown by itself, never in mixture; if mixed with grasses, they soon cause it to perish. As with lucerne, so here, weeds are very hurtful; hence, in certain cases, goat's-rue should be grown in rows which allow hoeing to be thoroughly done. Cultivated in this way, the largest produce is obtained. In the garden, goat's-rue is well adapted for covering trellis-work, and for borders.

Galega orientalis.

Werner, in the experimental field at Poppelsdorf, grew *Galega orientalis,* Lmk., which came from the Levant. He found that it developed more rapidly, in the spring, and was more herbaceous than officinal goat's-rue, though not so high in its growth.

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*) This includes one-third of the hard seeds. New seed germinated, in 23 days, 12 % and 88 % of the seeds remained hard: old seeds, in the same time, germinated 21 %; 21 % remained hard, and 58 % became rotten. If the hard seeds are not taken into account, old seed has a higher percentage of germination than new.

◆

Errata.

On Plate III read Cocksfoot instead of Cooksfoot.
Page 9, 7th line from above read (Pl. XVII) instead of (Pl. XV).
„ „ 21st „ „ „ „ (Pl. XXIV) „ „ (Pl. XII).

APPENDIX.

AMOUNT OF SEED TO BE SOWN.

TABLE I.—*Number of lbs. of perfectly pure and germinating seed required per acre.*

NAME.	Lbs. of pure and germinating seed.	LBS. OF PURE AND GERMINATING SEED WITH ADDITION OF :—							
		10 %	20 %	30 %	40 %	50 %*	60 %	70 %	80 %
1. Perennial Rye-grass	38.5	42.35	46.20	50.05	53.90	57.75	61.60	65.45	69.30
2. Italian Rye-grass	32.4	35.64	38.88	42.12	45.36	48.60	51.84	55.08	58.32
3. Cocksfoot	18.5	20.35	22.20	24·05	25.90	27.75	29.60	31.45	33.30
4. Meadow Fescue	37.0	40.7	44.4	48.1	51.8	55.5	59.2	62.9	66.6
5. False Oat-grass	34.5	37.95	41.40	44.85	48.30	51.75	55.20	58.65	62.10
6. Yellow Oat-grass	4.6	5.06	5.52	5.98	6.44	6.90	7.36	7.82	8.28
7. Yorkshire Fog	8.8	9.68	10.56	11.44	12.32	13.20	14.08	14.96	15.84
8. Timothy	14.0	15.4	16.8	18.2	19.6	21.0	22.4	23.8	25.2
9. Meadow Foxtail	6.2	6.82	7.44	8.06	8.68	9.30	9.92	10.54	11.16
10. Sweet-scented Vernal	7.8	8.58	9.36	10.14	10.92	11.70	12.48	13.26	14.04
11. Fiorin	7.0	7.7	8.4	9.1	9.8	10.5	11.2	11.9	12.6
12. Reed Canary Grass	12.0	13.2	14.4	15.6	16.8	18.0	19.2	20.4	21.6
13. Smooth-stalked Meadow Grass ...	8.4	9.24	10.08	10.92	11.76	12.60	13.44	14.28	15.12
14. Rough-stalked Meadow Grass ...	8.7	9.58	10.44	11.31	12.18	13.05	13.92	14.79	15.66
15. Alsike Clover	9.0	9.9	10.8	11.7	12.6	13.5	14.4	15.3	16.2
16. Sheep's Fescue	12.6	13.86	15.12	16.38	17.64	18.90	20.16	21.42	22.68
17. Sainfoin (shelled seed)	60.8	68.88	72.96	79.04	85.12	91.20	97.28	103.36	109.44
18. Various-leaved Fescue	19.5	21.45	23.40	25.35	27.30	29.25	31.20	33.15	35.10
20. Creeping Fescue	13.0	14.3	15.6	16.9	18.2	19.5	20.8	22.1	23.4
21. Upright Perennial Brome Grass	25.5	28.0	30.6	33.1	35.7	38.2	40.8	43.3	45.9
22. Awnless Brome Grass	35.6	39.16	42.72	46.28	49.84	53.40	56.96	60.52	64.08
23. Crested Dogstail	13.5	14.85	16.20	17.55	18.90	20.25	21.60	22.95	24.30
24. Red Clover...	15.8	17.38	18.96	20.54	22.12	23.70	25.28	26.86	28.44
25. White Clover	7.5	8.25	9.00	9.75	10.50	11.25	12.00	12.75	13.50
26. Common Kidney Vetch	15.0	16.5	18.0	19.5	21.0	22.5	24.0	25.5	27.0
27. Lucerne	22.0	24.2	26.4	28.6	30.8	33.0	35.2	37.4	39.6
28. Trefoil	15.25	16.77	18.30	19.82	21.35	22.87	24.40	25.92	27.45
29. Bird's-foot Trefoil	4.67	5.14	5.60	6.07	6.54	7.00	7.47	7.94	8.41
30. Officinal Goat's Rue	6.9	7.59	8.28	8.97	9.66	10.35	11.04	11.73	12.42

* This column is, as a rule, to be used in calculating the amounts for permanent mixtures.

TABLE II.—*Number of lbs. of average commercial seed required per acre.*

NAME.	Percentage of pure and germinating seed.	Lbs. of seed required.	LBS. OF SEED WITH ADDITION OF :—							
			10 %	20 %	30 %	40 %	50 %*	60 %	70 %	80 %
1. Perennial Rye-grass	71	54	59.4	64.8	70.2	75.6	81.0	86.4	91.8	97.2
2. Italian Rye-grass	67	48	52.8	57.6	62.4	67.2	72.0	76.8	81.6	86.4
3. Cocksfoot	53	35	38.5	42.0	45.5	49.0	52.5	56.0	59.5	63.0
4. Meadow Fescue	71	52	57.2	62.4	67.6	72.8	78.0	83.2	88.4	93.6
5. False Oat-grass...	49	70	77.0	84.0	91.0	98.0	105.0	112.0	119.0	126.0
6. Yellow Oat-grass	16	29	31.9	34.8	37.7	40.6	43.5	46.4	49.3	52.2
7. Yorkshire Fog	40	22	24.2	26.4	28.6	30.8	33.0	35.2	37.4	39.6
8. Timothy	87	16	17.6	19.2	20.8	22.4	24.0	25.6	27.2	28.8
9. Meadow Foxtail	27	23	25.3	27.6	29.9	32.2	34.5	36.8	39.1	41.4
10. Sweet-scented Vernal	26	30	33.0	36.0	39.0	42.0	45.0	48.0	51.0	54.0
11. Fiorin	72	9.7	10.7	11.6	12.6	13.6	14.5	15.5	16.5	17.5
12. Reed Canary Grass	57	21	23.1	25.2	27.3	29.4	31.5	33.6	35.7	37.8
13. Smooth-stalked Meadow Grass	48	17.5	19.2	21.0	22.7	24.4	26.2	27.9	29.7	31.5
14. Rough-stalked Meadow Grass	45	19.5	21.4	23.4	25.3	27.3	29.2	31.2	33.1	35.1
15. Alsike Clover	73	12	13.2	14.4	15.6	16.8	18.0	19.2	20.4	21.6
16. Sheep's Fescue	45	28	30.8	33.6	36.4	39.2	42.0	44.8	47.6	50.4
17. Sainfoin (shelled seed)... ...	78	78	85.8	93.6	101.4	109.2	117.0	124.8	132.6	140.4
18. Various-leaved Fescue... ...	58	33.5	36.9	40.2	43.6	46.9	50.3	53.6	57.0	60.3
20. Creeping Fescue	42.5	30	33.0	36.0	39.0	42.0	45.0	48.0	51.0	54.0
21. Upright Perennial Brome Grass	51	50	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0
22. Awnless Brome Grass... ...	81	44	48.4	52.8	57.2	61.6	66.0	70.4	74.8	79.2
23. Crested Dogstail	54	25	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0
24. Red Clover	88	18	19.8	21.6	23.4	25.2	27.0	28.8	30.6	32.4
25. White Clover	74	10	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0
26. Common Kidney Vetch ...	86	17.5	19.2	21.0	22.7	24.4	26.2	27.9	29.7	31.5
27. Lucerne	88	25	27.5	30.0	32.5	35.0	37.5	40.0	42.5	45.0
28. Trefoil	83	18.5	19.8	21.6	23.4	25.2	27.0	28.8	30.6	32.4
29. Bird's-foot Trefoil	43	11	12.1	13.2	14.3	15.4	16.5	17.6	18.7	19.8
30. Officinal Goat's Rue	31	22	24.2	26.4	28.6	30.8	33.0	35.2	37.4	39.6

* This column is, as a rule, to be used in calculating the amounts for permanent mixtures.

TABLE III.—*The nutritive value of 100 lbs. of hay containing 14% water.*

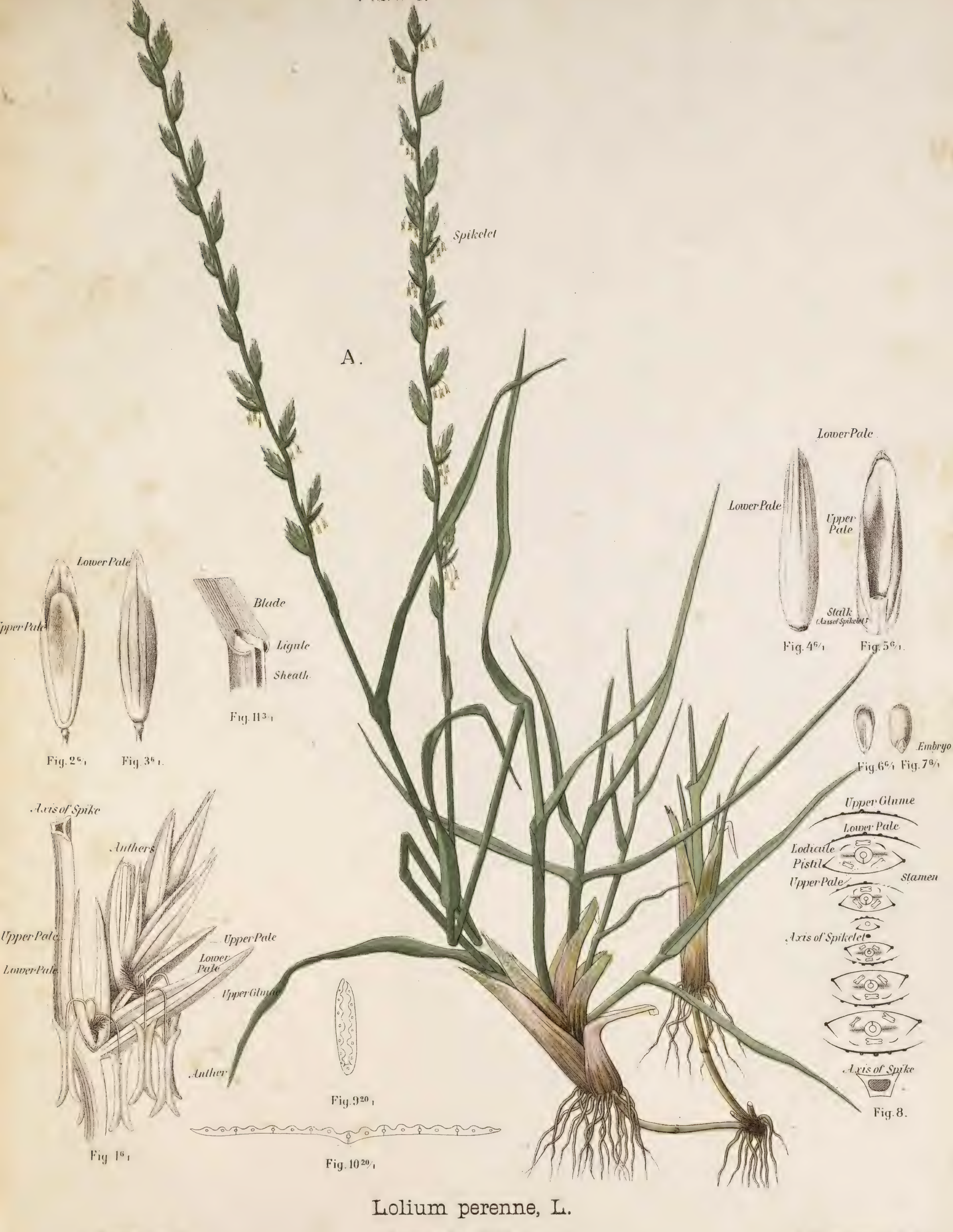
NAME.	AUTHORITY OR ANALYST.	Ash.	Organic matter.	The organic matter is composed of :—			
				Albumen (N × 6.25).	Fat.	Woody Fibre.	Non-nitrogenous extractives.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1. Perennial Rye-grass	Wolff	6.5	79.5	10.2	2.7	30.3	36.3
2. Italian Rye-grass	Wolff	7.9	78.1	11.2	3.2	23.0	40.8
3. Cocksfoot	Way	4.6	81.4	11.6	2.7	29.0	38.1
"	Ritthausen and Scheven	5.9	80.1	7.4	2.0	39.6	31.1
"	Collier	7.5	78.5	7.2	3.0	21.4	46.9
" leaves from second cutting	Frey	9.6	76.4	10.2	3.0	25.2	38.0
4. Meadow Fescue	Ritthausen and Scheven	5.7	80.3	8.3	2.7	34.5	34.8
" "	Wolff	4.5	81.5	10.2	1.8	32.6	36.9
" "	Arendt	6.2	79.8	6.4	1.8	—	—
" "	Collier	8.1	77.9	9.2	2.8	20.8	45.1
5. False Oat Grass	Wolff	9.9	76.1	11.1	2.7	29.5	32.4
6. Yellow Oat Grass	Way	5.9	80.1	6.4	2.3	30.9	40.5
" "	Ritthausen and Scheven	6.2	79.8	7.0	1.7	34.6	36.5
7. Yorkshire Fog	Way	5.5	80.5	9.9	3.1	33.8	33.7
"	Ritthausen and Scheven	8.3	77.7	7.9	1.7	35.3	32.8
8. Timothy	Wolff	4.5	81.5	9.7	3.0	22.8	46.0
"	Frey	6.7	79.3	5.9	2.6	29.9	40.9
9. Meadow Foxtail	Way	6.6	79.4	10.6	2.5	29.1	37.2
" "	Ritthausen and Scheven	5.4	80.6	7.0	2.1	40.1	31.4
" "	Frey	10.6	75.4	6.9	1.5	27.8	39.2
" " leaves second cutting	Frey	7.9	78.1	10.9	3.8	28.1	35.3
10. Sweet Scented Vernal	Frey	5.1	80.9	6.8	1.8	29.4	42.9
" "	Way	5.4	80.6	8.9	2.9	31.3	37.5
" "	Wolff	5.1	80.9	4.8	—	36.9	39.2*
" "	Peters	6.3	79.7	8.6	2.9	22.1	46.1
" "	Collier	7.6	78.4	7.3	2.9	22.1	46.1
12. Reed Canary Grass	Barbieri	7.2	78.8	4.2	1.2	29.8	43.6
" "	Ritthausen and Scheven	7.2	78.8	5.3	1.1	37.4	35.0
13. Smooth Stalked Meadow Grass	Barbieri	6.2	79.8	6.2	1.4	41.9	30.3
" " "	Way	5.1	80.9	8.9	2.3	32.7	37.0
" " "	Ritthausen and Scheven	4.1	81.9	9.1	2.5	35.4	34.9
" " "	Collier	4.5	81.5	10.0	2.5	24.0	45.0
" " "	Collier	4.7	81.3	6.4	4.2	19.4	51.3
14. Rough Stalked Meadow Grass	Barbieri	9.0	77.0	6.1	2.2	29.9	38.8
" " "	Ritthausen and Scheven	6.2	79.8	9.0	3.2	34.5	33.1
" " "	Way	7.1	78.9	8.4	3.2	33.0	34.3
15. Alsike Clover	Wolff	6.2	79.8	15.4	3.4	27.6	33.4
16. Sheep's Fescue	Barbieri	7.8	78.2	7.4	3.0	31.6	36.2
" "	Collier	4.3	81.7	5.6	3.7	72.4	
" "	Way	4.6	81.4	10.4	2.9	33.3	34.8
" "	Wolff	6.4	79.6	13.7	2.6	27.9	35.4
17. Sainfoin	Barbieri	8.1	77.9	5.5	2.8	38.9	3.0
18. Various-leaved Fescue	Barbieri	12.9	73.1	10.6	3.0	22.6	36.2
19. Alpine Meadow Grass (viviparous variety)	Barbieri	6.9	79.1	4.9	2.4	33.5	38.3
20. Creeping Fescue	Ritthausen and Scheven	5.6	80.4	7.8	1.6	39.2	31.8
" "	Barbieri	5.7	80.3	8.9	2.2	32.1	37.1
21. Upright Perennial Brome Grass	Way	4.5	81.5	8.1	2.8	70.6	
22. Awnless Brome Grass	Barbieri	7.6	78.3	4.9	1.6	36.9	34.9
23. Crested Dogstail	Way	5.6	80.4	9.5	3.1	22.6	45.2
" "	Ritthausen and Scheven	7.2	78.8	6.6	2.2	36.7	33.3
" "	Arendt	7.1	78.9	14.3	3.5	—	—
24. Red Clover, low quality	Wolff	5.2	80.8	11.2	2.1	29.3	38.2
" medium quality	Wolff	5.4	80.6	12.7	2.2	26.6	39.1
" very good quality	Wolff	6.2	79.8	13.9	3.0	24.7	38.2
" excellent quality	Wolff	7.2	78.8	15.7	3.3	22.9	36.9
25. White Clover	Wolff	6.2	79.8	14.9	3.6	26.4	34.9
26. Common Kidney Vetch	Wolff	6.6	79.4	14.2	2.6	26.3	36.3
" "	Barbieri	9.3	76.7	12.8	1.9	36.4	25.6
27. Lucerne, average quality	Wolff	6.4	79.6	14.8	2.6	33.7	28.5
" very good quality	Wolff	7.0	79.0	16.5	2.6	27.4	32.5
28. Trefoil	Wolff	6.2	79.8	15.1	3.4	27.1	34.2
29. Bird's Foot Trefoil	Barbieri	8.1	77.9	15.7	3.7	22.0	36.5
" "	Ritthausen and Scheven	6.6	79.4	13.3	—	21.9	44.2*
30. Officinal Goat's Rue	Barbieri	7.3	78.7	17.1	1.4	34.1	26.1
Meadow Hay of average quality	**Wolff**	**6.2**	**79.8**	**9.7**	**2.5**	**26.4**	**41.6**

* Including fat.

TABLE IV.—*Quantity of mineral matter removed from the soil by 1,000 lbs. of hay containing 14% water.*

NAME OF PLANT.	AUTHORITY OR ANALYST.	Ash.	Nitrogen.	THE ASH IS COMPOSED OF :—								
				Phosphoric Acid.	Potash.	Soda.	Lime.	Magnesia.	Sulphuric Acid.	Silica.	Oxide of Iron.	Chlorine.
		lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1. Perennial Rye-grass	Wolff	104.2	18.9	10.0	39.3	1.3	10.6	2.4	6.0	29.7	1.1	5.8
2. Italian Rye-grass	Way and Ogoston ...	59.9	20.8	3.8	7.5	3.1	6.0	1.3	1.7	35.5	0.5	8.3
3. Cocksfoot	Wolff	51.0	18.3	2.7	16.8	2.2	3.1	1.5	1.3	16.8	0.9	3.6
4. Meadow Fescue	G. Witting, jun. ...	89.1	14.7	7.4	25.6	5.2	9.2	3.9	1.7	22.8	3.9	11.2
" "	Arendt	62.1	10.1	4.5	...	...	3.2	2.2	...	25.5	0.7	...
5. False Oat-grass	Arendt	71.0	18.4	5.0	...	...	3.8	...	...	27.8	1.2	...
6. Yellow Oat-grass	Way and Ogoston ...	45.4	10.1	4.2	16.4	0.6	3.6	1.4	1.8	16.0	1.1	0.3
7. Yorkshire Fog...	Way and Ogoston ...	53.8	14.3	4.4	20.4	1.9	4.6	1.9	2.4	15.5	0.2	3.2
" "	Knop and Arendt ...	76.1	24.1	4.8	...	...	4.6	1.4	...	39.0	1.4	...
8. Timothy	Wolff	58.7	15.5	6.9	20.4	1.1	4.7	1.9	1.7	18.9	0.5	3.0
9. Meadow Foxtail	Way and Ogoston ...	66.7	13.1	4.2	28.9	...	2.6	0.9	1.5	26.0	0.3	3.0
10. Sweet-scented Vernal... ...	Arendt	63.5	17.5	3.9	...	...	2.2	1.0	...	30.4	0.5	...
" "	Way and Ogoston ...	53.7	11.7	5.5	19.8	1.4	5.0	1.3	1.8	15.4	0.6	3.4
12. Reed Canary Grass	Barbieri (experimental field)	65.6	6.7	7.1	18.9	0.3	2.7	0.9	3.4	30.6	...	1.0
13. Smooth-stalked Meadow Grass	Barbieri (exp. field)	59.3	9.9	8.2	15.0	0.5	1.9	0.4	1.3	24.3	...	4.0
" " "	Way and Ogoston ...	51.9	...	5.2	20.0	0.4	2.9	1.4	2.2	17.2	0.2	3.2
" " "	Knop and Arendt ...	61.8	16.6	3.9	...	...	4.3	2.0	...	27.0	1.0	...
" " "	Collier	44.5	15.8	4.4	18.8	...	2.1	1.4	2.1	13.5	...	2.8
14. Rough-stalked Meadow Grass	Barbieri	82.6	9.8	12.7	26.3	1.1	7.2	1.2	4.2	19.3	...	10.1
15. Alsike Clover	Wolff	40.6	24.6	4.1	11.3	1.2	13.8	5.1	1.7	1.7	0.2	2.2
16. Sheep's Fescue...	Barbieri (exp. field)	63.9	11.7	4.6	16.8	0.2	2.5	0.6	1.7	37.3	0.1	1.5
" "	Hurschauer... ...	28.1	...	3.0	4.7	3.5	6.5	2.3	1.2	6.0	0.8	0.1
17. Sainfoin	Wolff	47.3	21.9	4.7	13.4	1.5	17.3	3.1	1.4	3.8	0.5	1.8
18. Various-leaved Fescue ...	Barbieri (exp. field)	77.7	8.7	10.7	14.1	0.6	2.5	0.3	1.9	44.0	...	4.8
19. Alpine Meadow Grass ...	Barbieri (exp. field)	123.7	16.9	14.1	36.0	2.3	8.1	4.8	5.0	43.1	2.3	9.0
20. Creeping Fescue	Barbieri (exp. field)	63.5	7.9	9.0	11.5	0.5	3.9	0.4	1.8	32.7	...	3.3
21. Upright Perennial Brome Grass	Barbieri	53.4	14.3	6.8	16.8	1.1	4.4	1.9	1.8	15.2	0.5	3.5
" " "	Way and Ogoston ...	44.5	...	3.4	12.1	0.3	4.6	2.2	2.4	17.2	0.1	2.6
22. Awnless Brome Grass ...	Barbieri (exp. field)	63.3	7.7	8.3	16.3	0.6	3.4	0.8	2.6	30.1	trace	1.5
23. Crested Dogstail	Way and Ogoston ...	54.9	13.7	4.0	17.7	...	5.6	1.3	1.8	22.0	0.1	1.2
" "	Arendt	70.6	22.8	5.4	...	...	3.2	1.3	...	29.7	0.9	...
24. Red Clover	Wolff	59.0	19.7	5.7	19.0	1.2	20.6	6.4	1.9	1.6	0.6	2.2
25. White Clover	Wolff	63.0	22.5	8.0	13.5	4.6	19.0	5.9	4.7	2.8	1.3	2.7
26. Common Kidney Vetch ...	Wolff	54.9	22.8	4.8	14.9	0.7	28.5	2.5	0.7	1.8	0.7	0.5
" " " ...	Barbieri (exp. field)	90.2	20.5	9.2	25.4	1.1	24.9	3.0	2.8	16.2	0.9	6.0
27. Lucerne	Wolff	85.9	23.6	7.3	21.9	1.5	34.9	4.2	4.9	8.2	1.6	2.5
28. Trefoil	Anderson & Marchand	55.5	24.2	4.6	17.3	4.5	15.4	4.7	2.2	1.9	0.7	4.9
29. Bird's-foot Trefoil	Barbieri	79.1	25.1	10.9	23.3	0.9	20.8	5.2	2.4	7.3	1.6	4.5
30. Official Goat's Rue	Barbieri (exp. field)	71.8	27.3	8.9	25.4	2.0	14.3	2.8	3.4	8.9	0.7	4.5
Meadow Hay...	**Wolff ... ...**	**60.0**	**15.5**	**4.3**	**16.0**	**2.2**	**9.6**	**4.1**	**3.1**	**17.2**	**0.9**	**3.7**

Plate I.



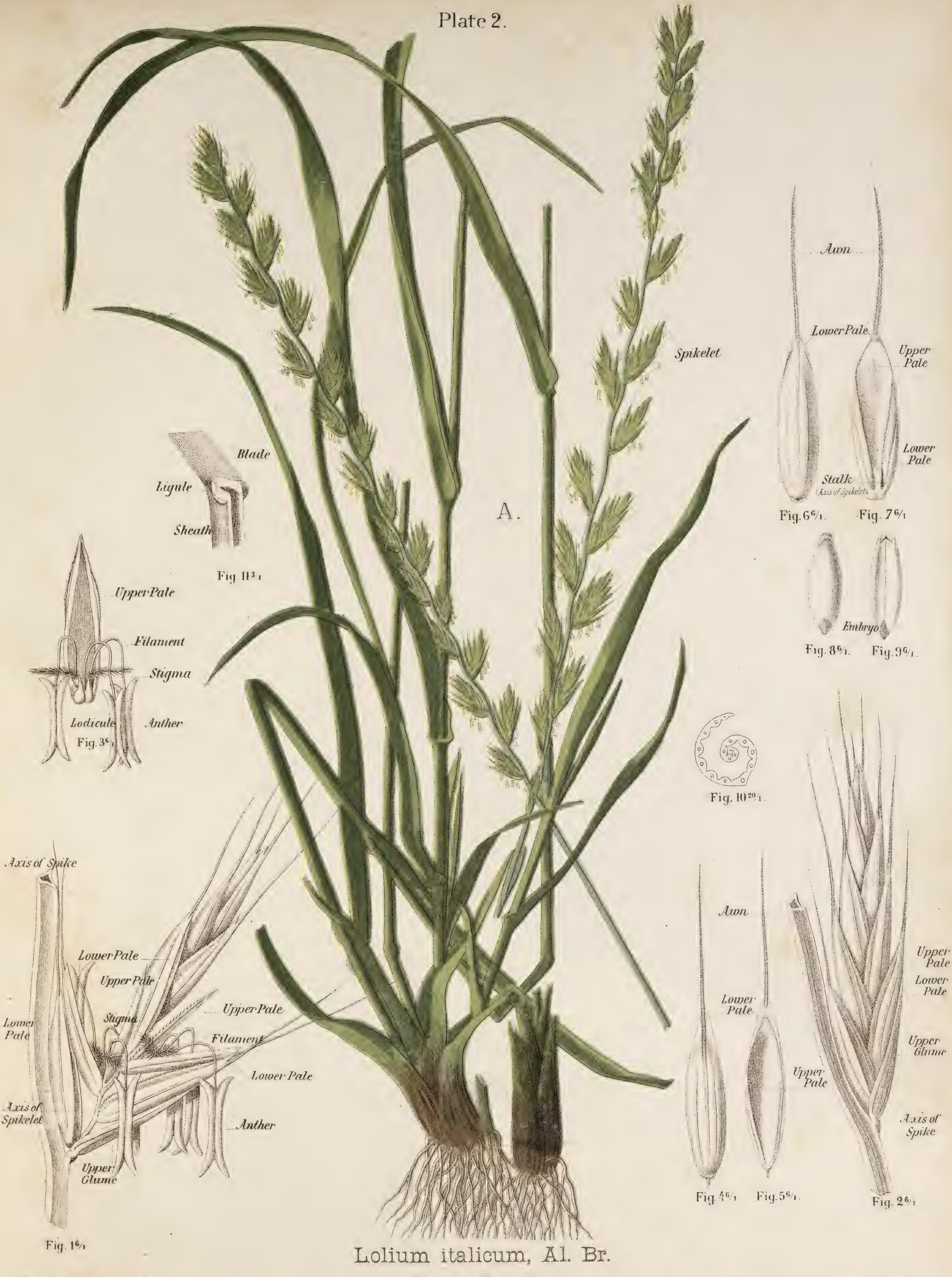
Lolium perenne, L.

C. & L. Schröter ad. nat. del.

Perennial Rye grass.

v. Lith. Genossenschaft Zürich.

Plate 2.



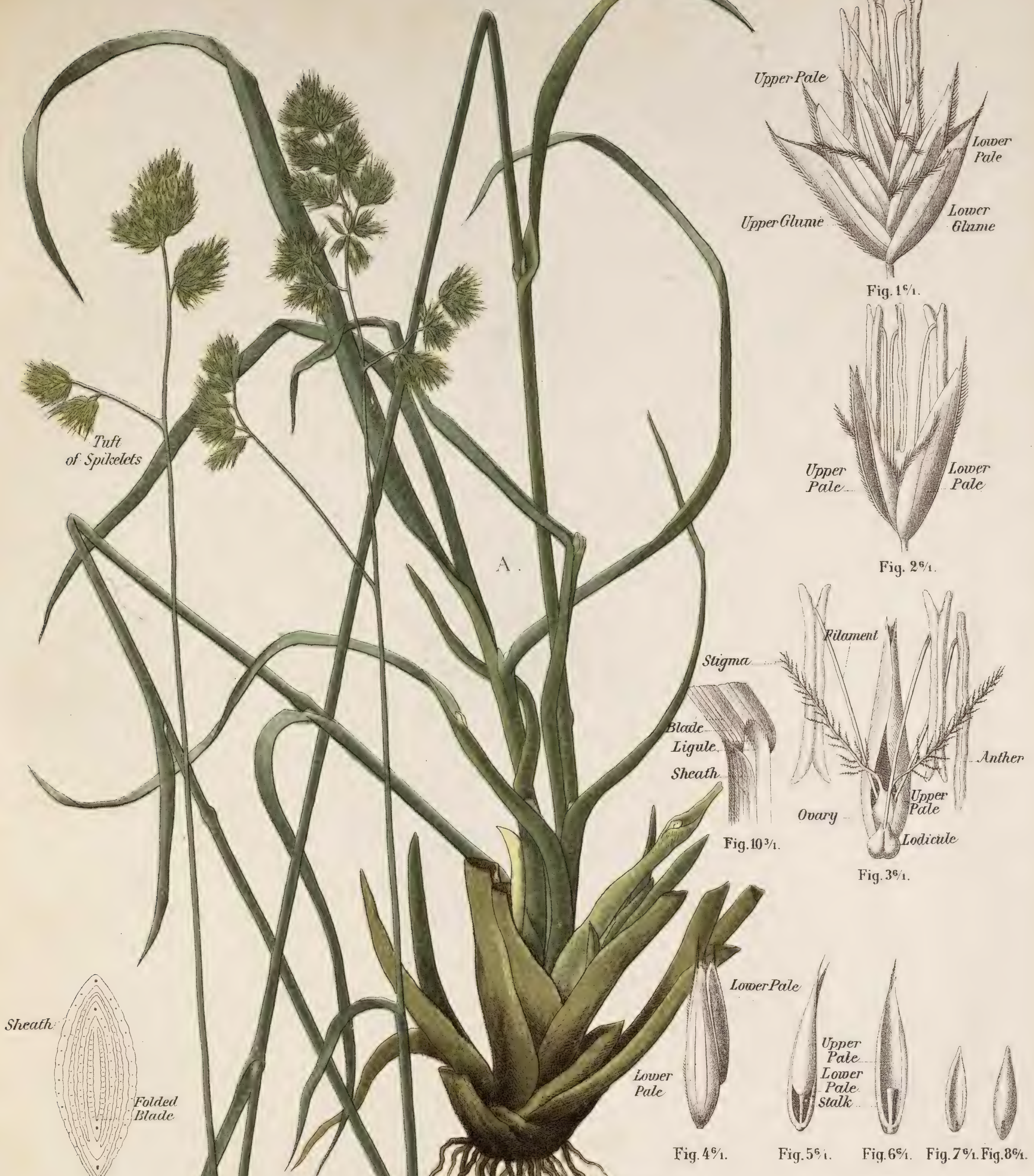
Lolium italicum, Al. Br.

Italian Rye grass.

C. & L. Schröter ad. nat. del.

v. Lith. Genossenschaft Zürich.

Plate 3.

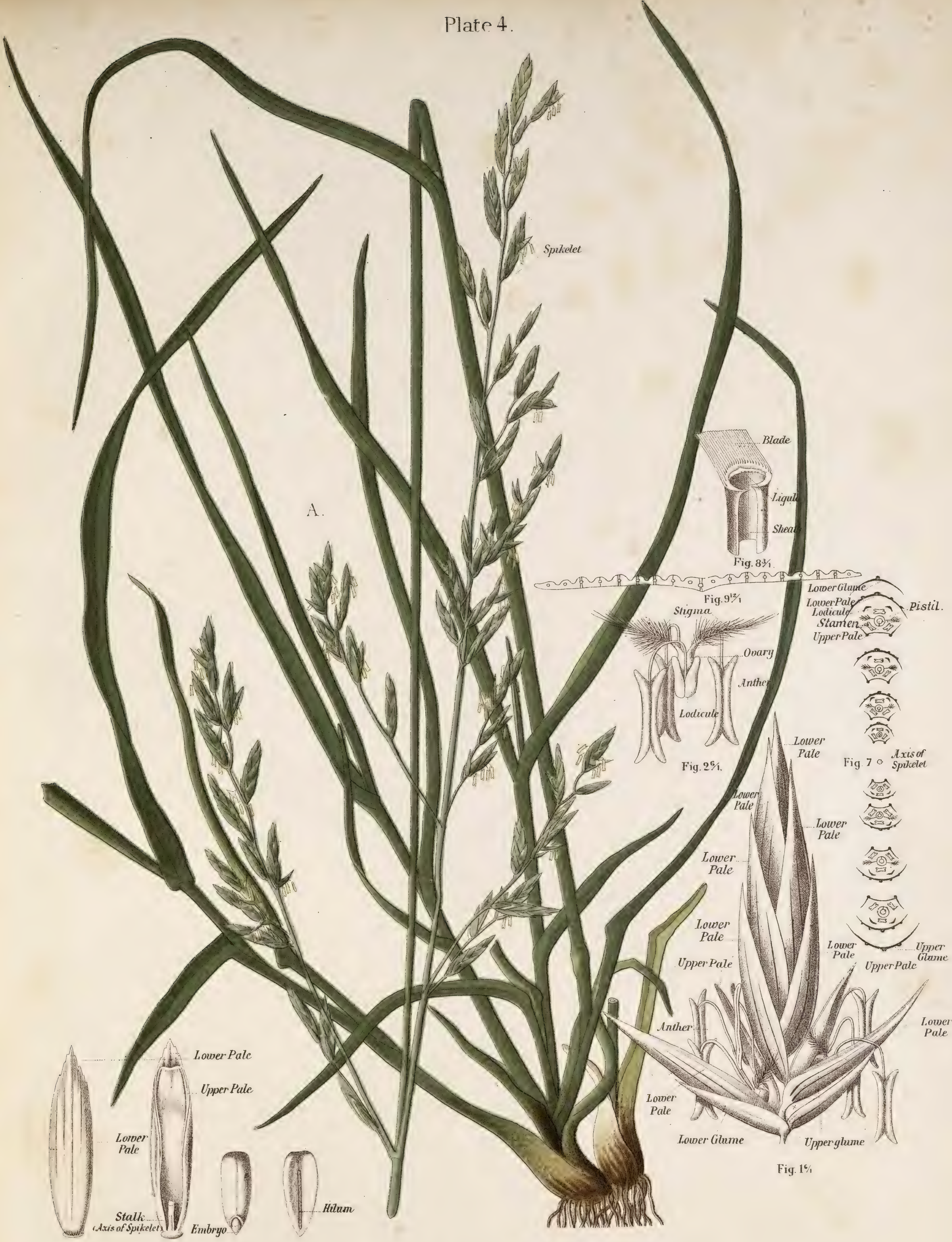


Dactylis glomerata. L.
Cooksfoot.

C. & L. Schröter ad. nat. del.

v. Lith. Genossenschaft Zürich.

Plate 4.



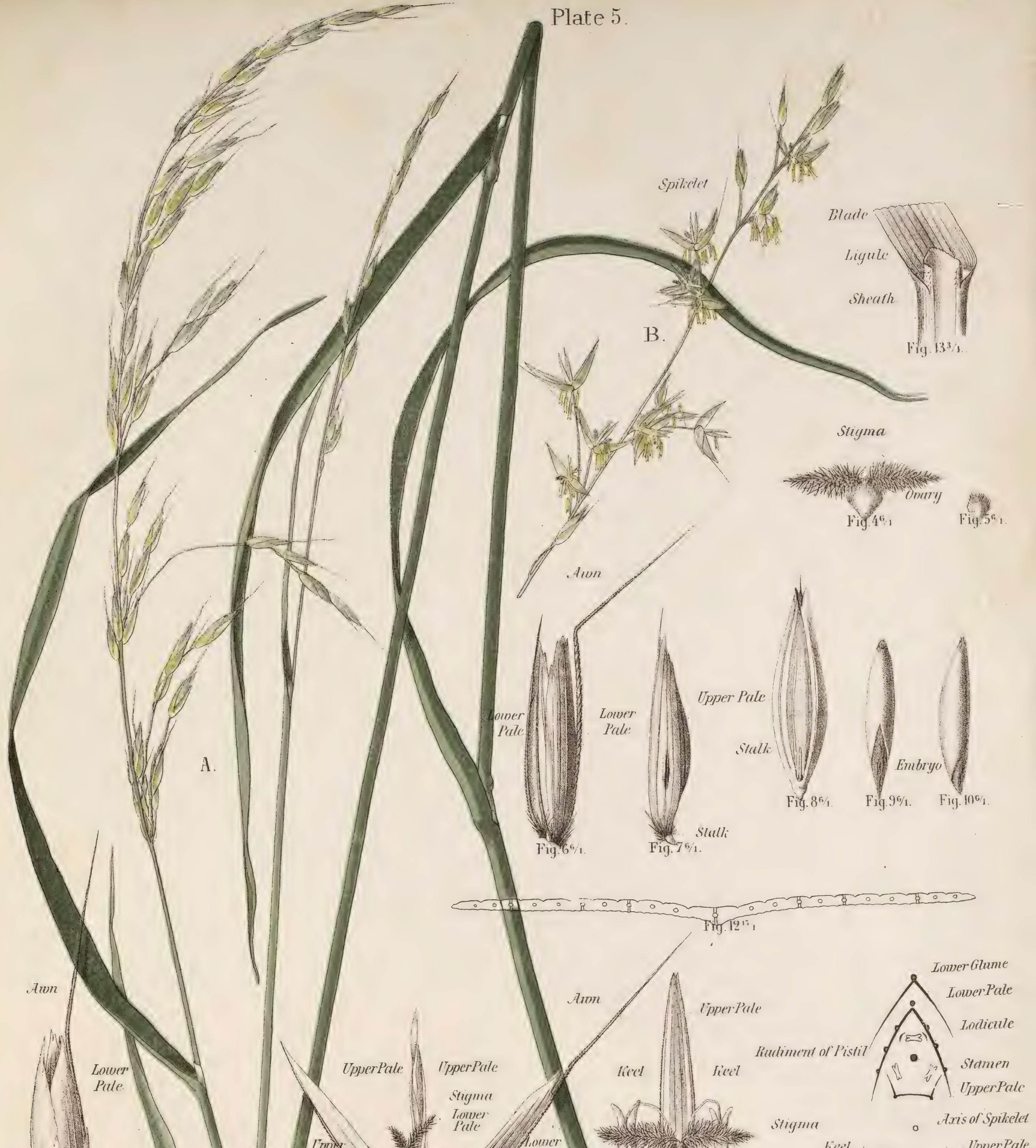
Festuca pratensis, Huds.

Meadow Fescue

C. & L. Schröter ad. nat. del.

v. Lith. Genossenschaft Zürich.

Plate 5.



Arrhenatherum elatius, M. u. K.

False Oat-grass

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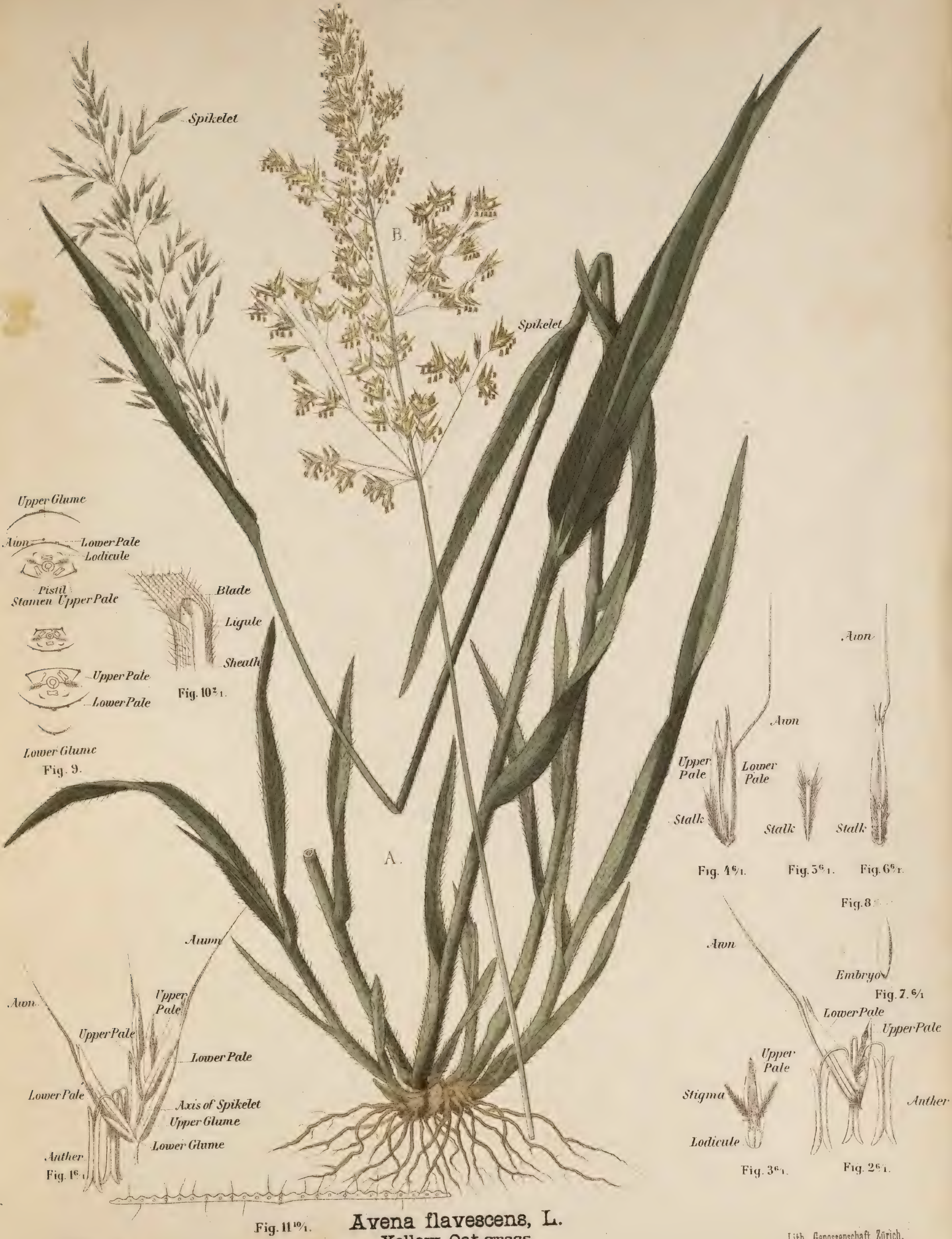
v. Lith. Genossenschaft Zürich.

Plate 6.



Avena flavescens, L.
Yellow Oat-grass.

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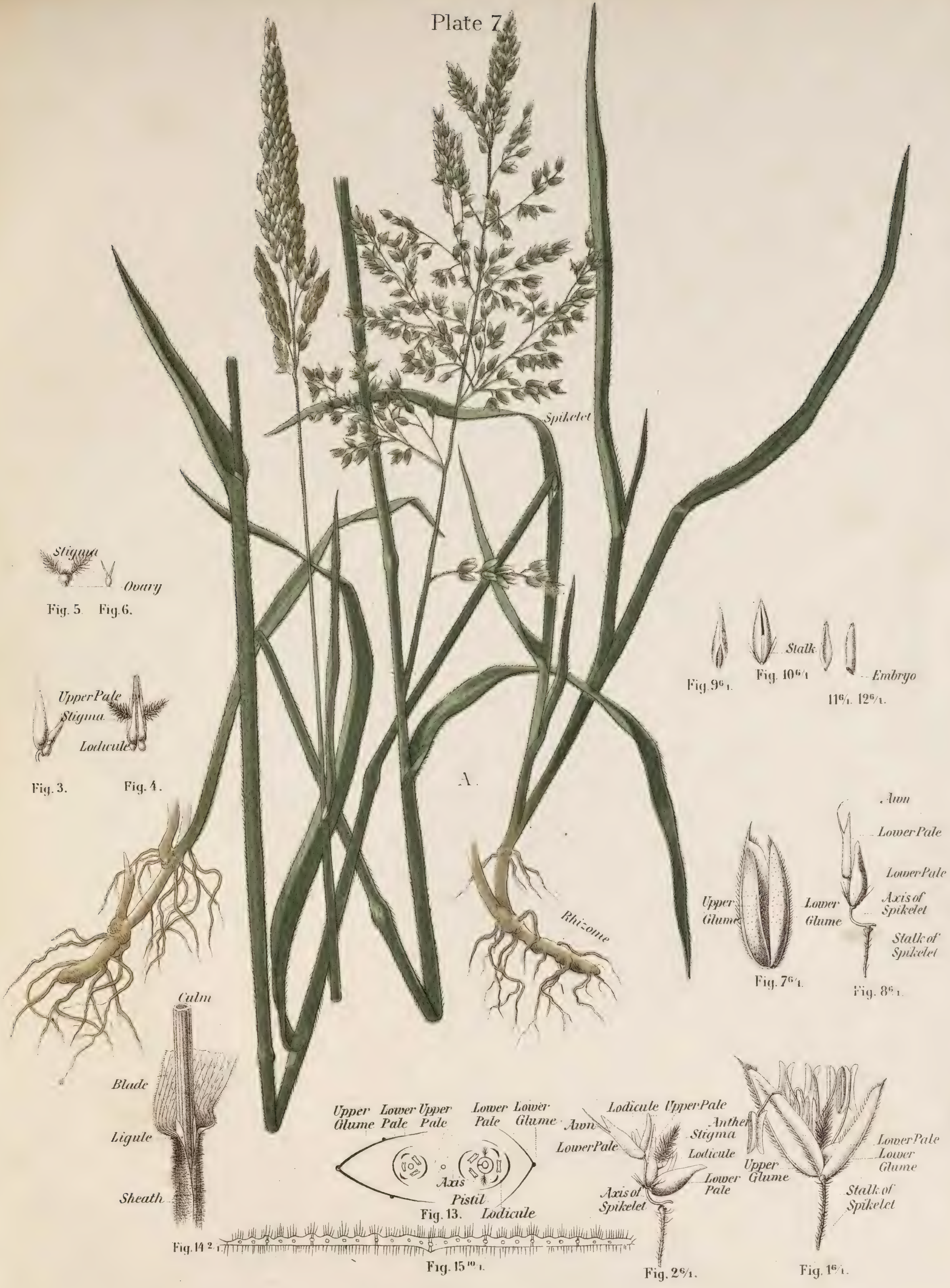
Lith. Genossenschaft Zürich.

Plate 7



Holcus lanatus, L.

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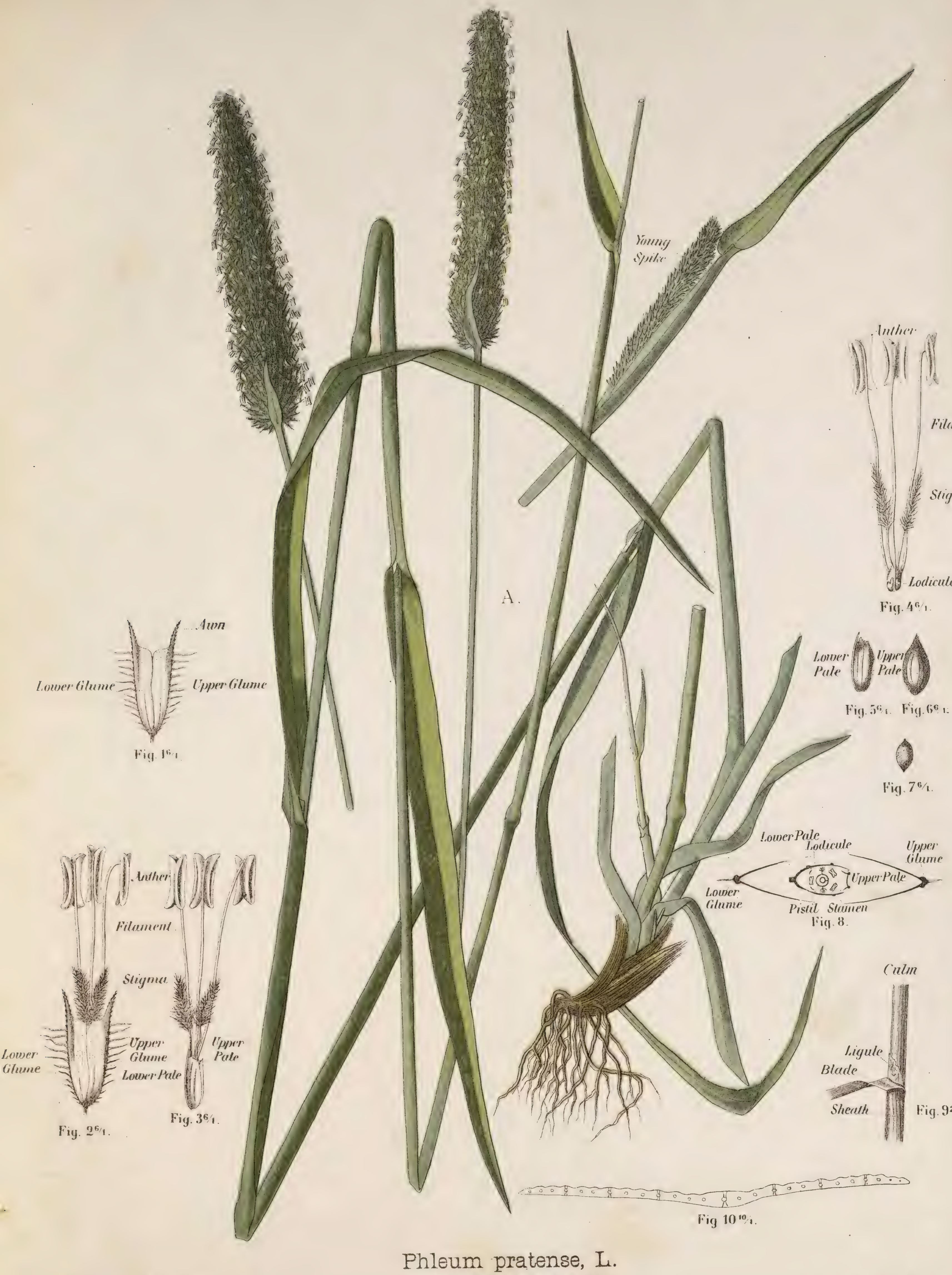
Yorkshire Fog

v. Lith. Genossenschaft Zürich.

Plate 8.



Phleum pratense, L.

Timothy or Catstail

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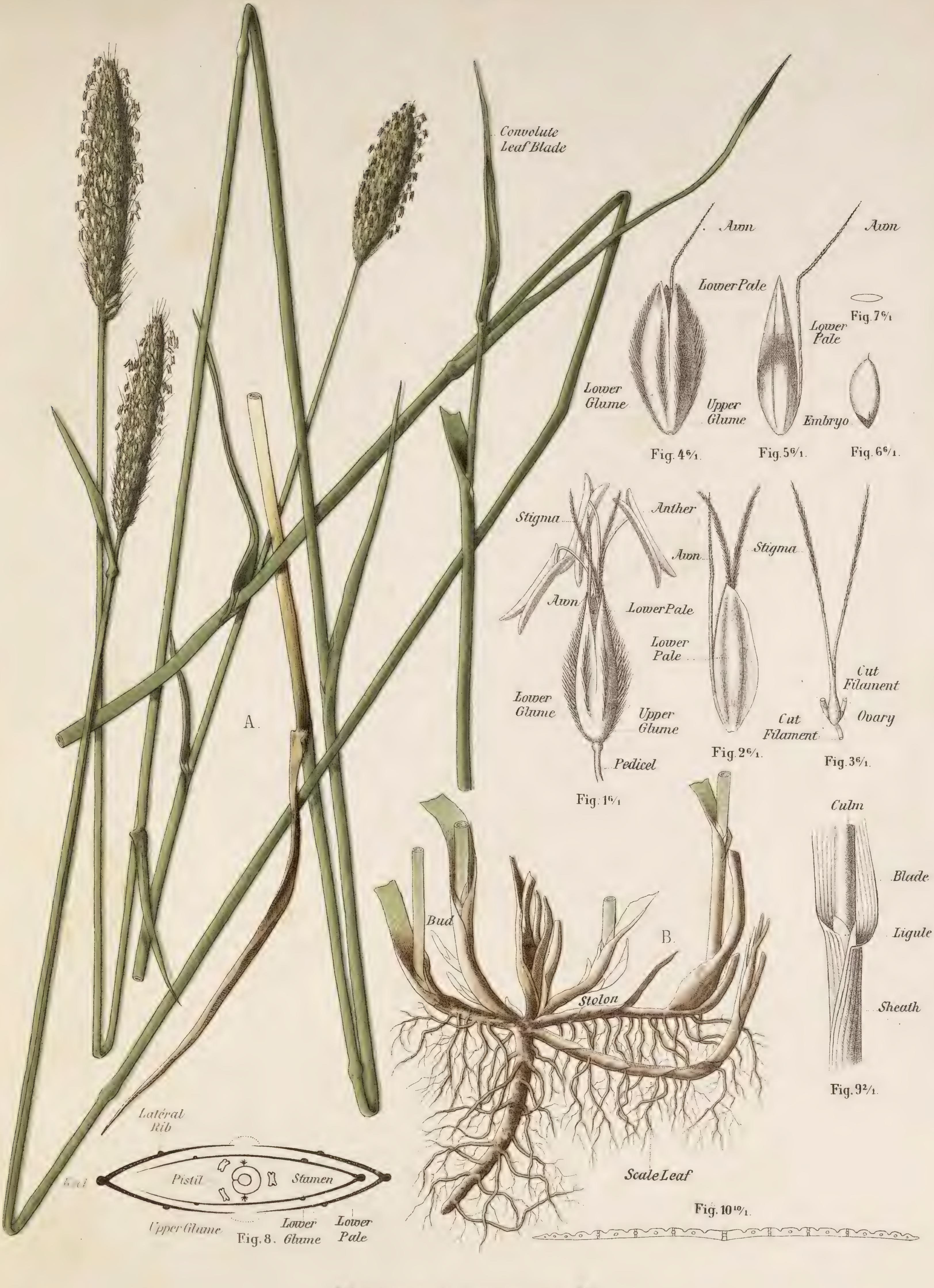
v. Lith. Genossenschaft Zürich.

Plate 9.



Alopecurus pratensis, L.

Meadow Foxtail

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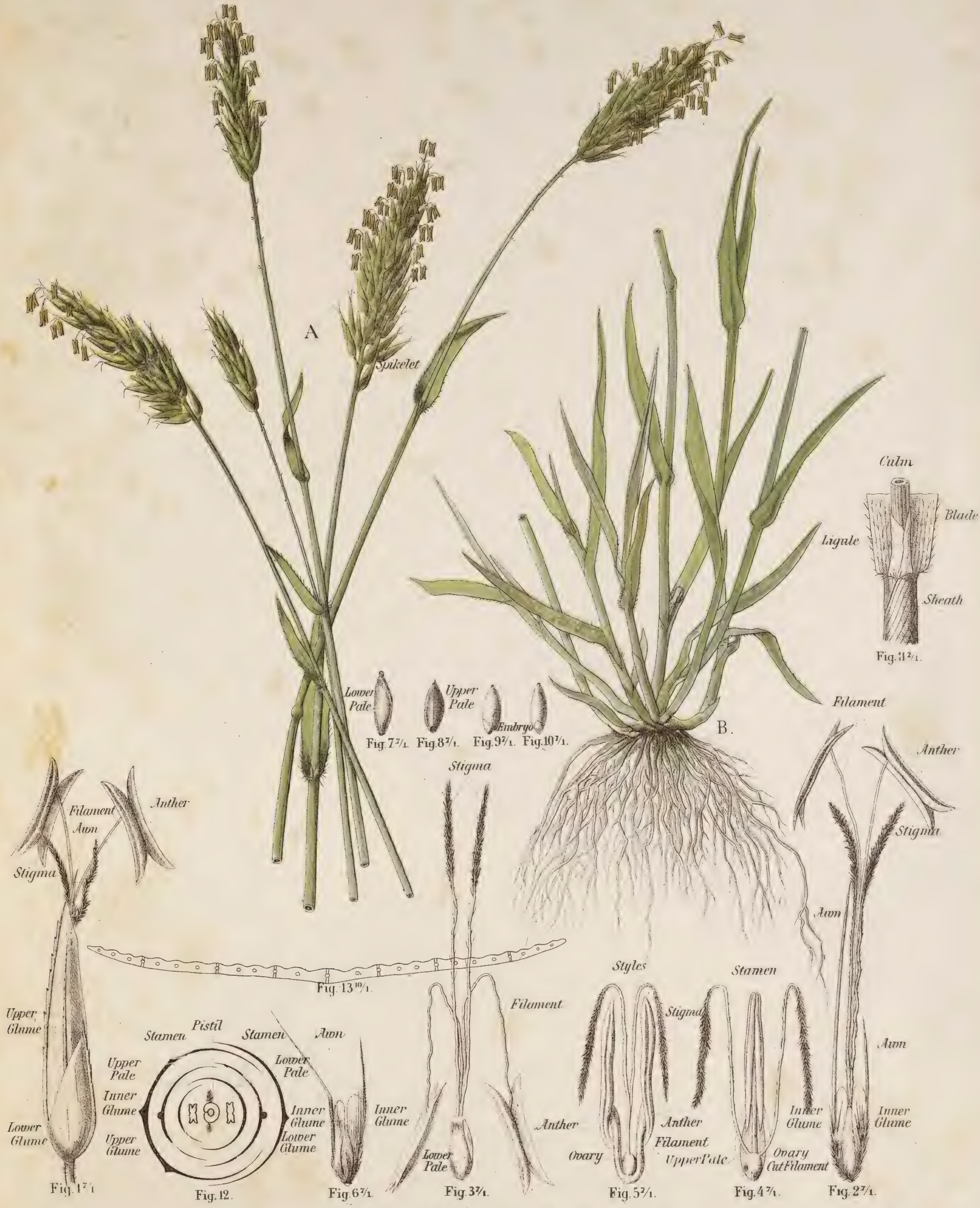
v. Lith. Genossenschaft Zürich.

Plate 10.



Anthoxanthum odoratum, L.
Sweet-scented grass

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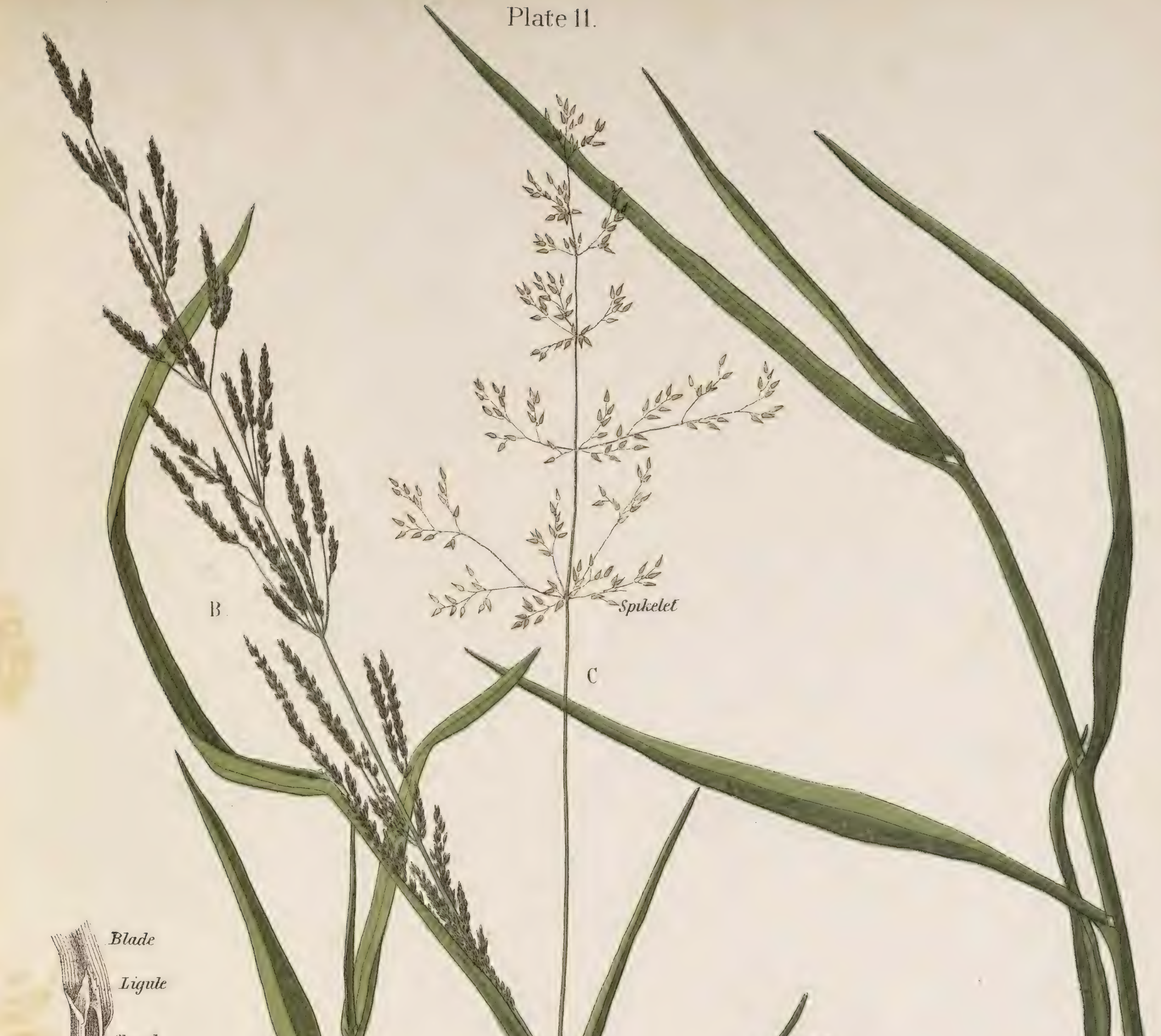
v. Lith. Genossenschaft Zürich.

Plate 11.



Agrostis stolonifera, L.

Fiorin or Stoloniferous Bent Grass

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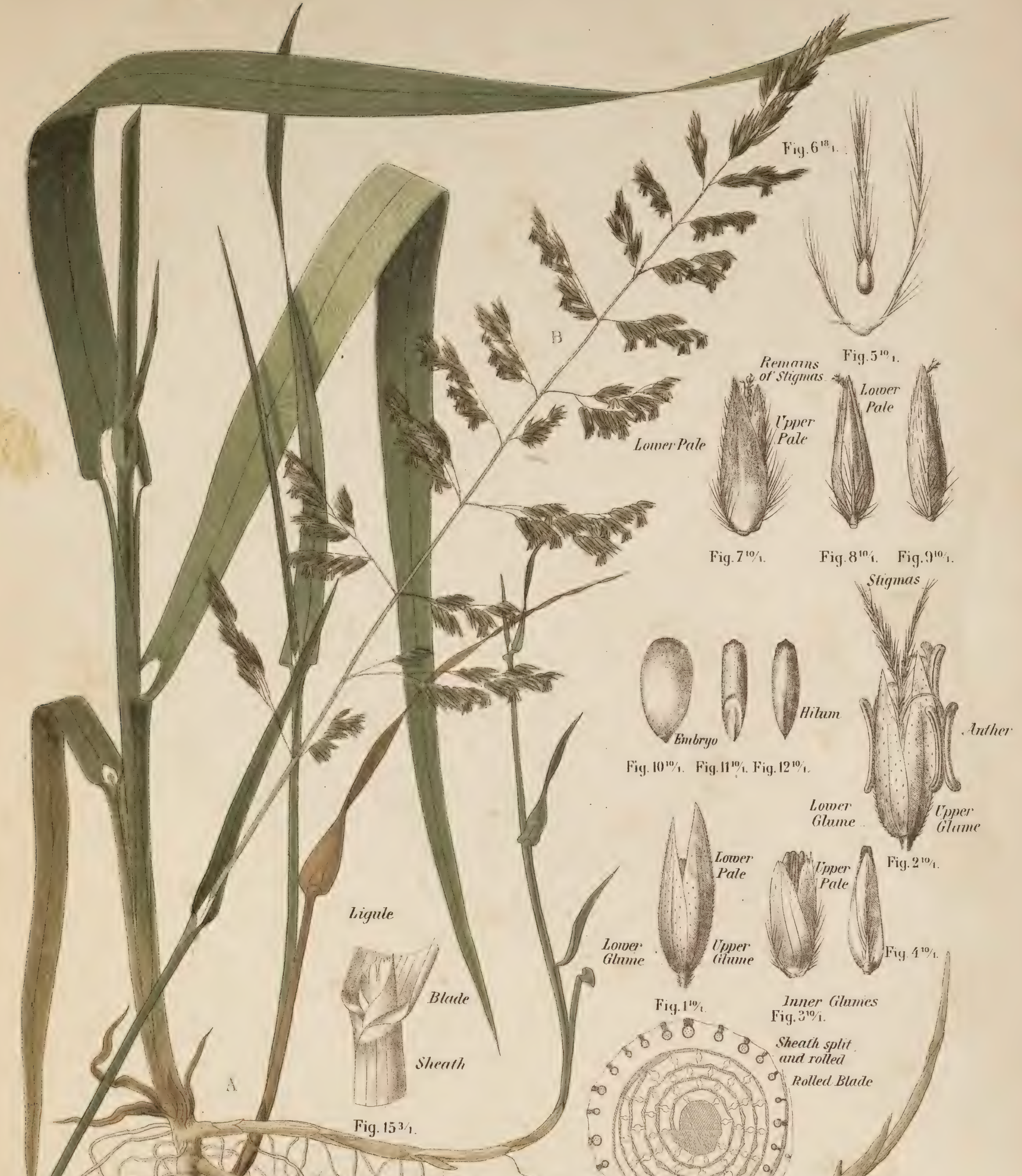
v. Lith. Genossenschaft Zürich.

Plate 12.



Phalaris arundinacea, L.

Reed Canary Grass.

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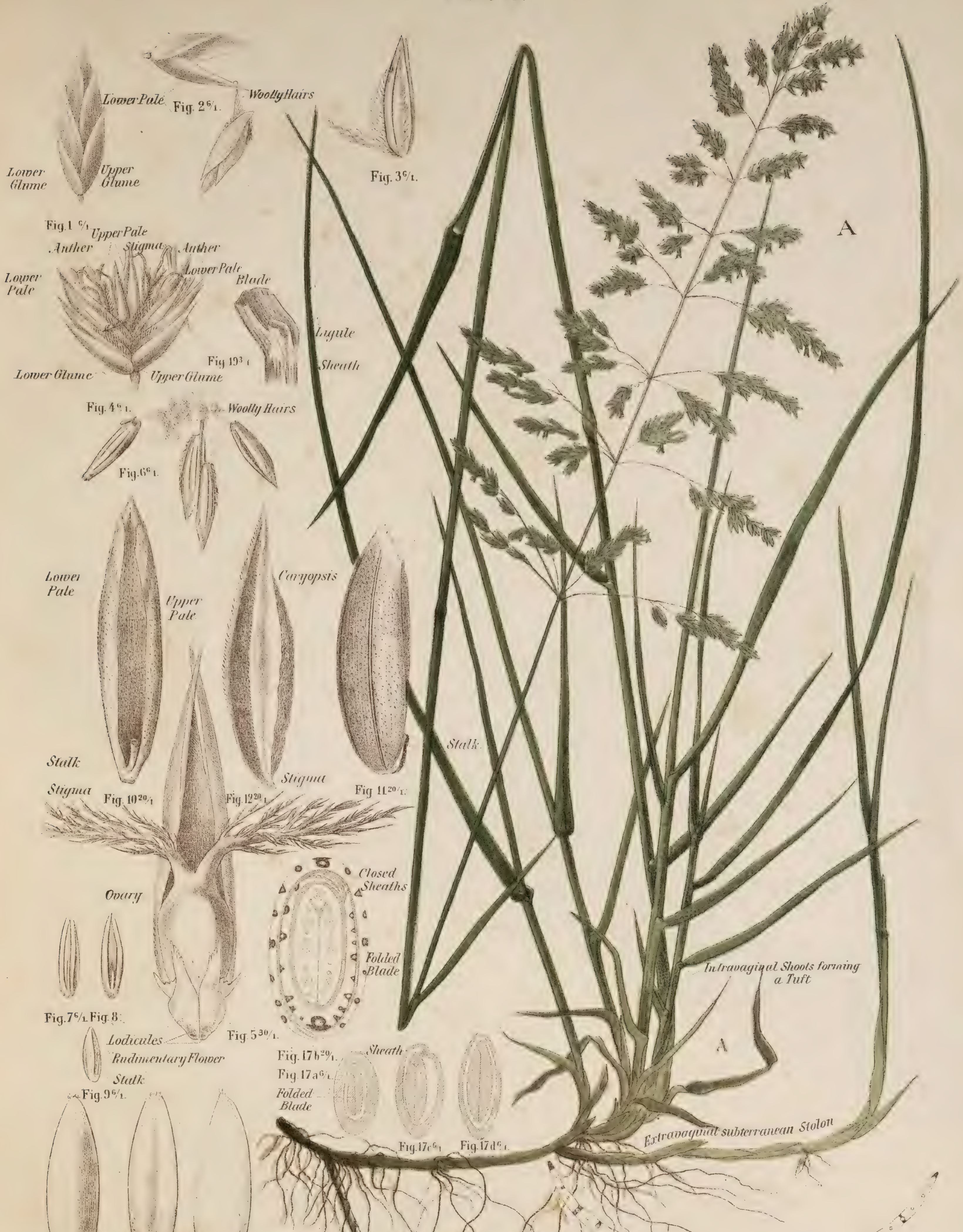
Plate 13.



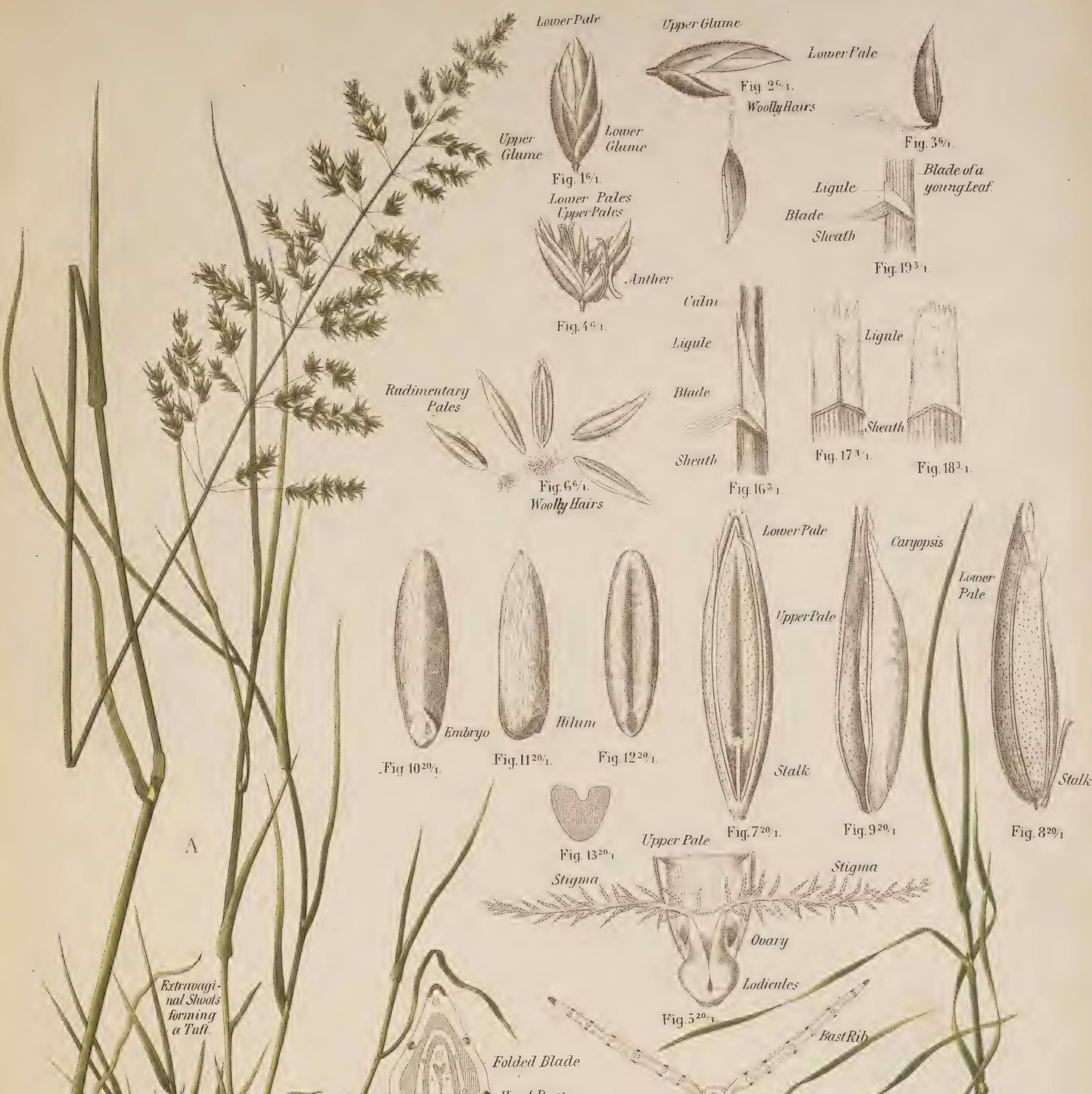
Poa pratensis, L.

Smooth-stalked Meadow grass.

C. & L. Schröter ad. nat. del.

Plate 14

Plate 14.



Poa trivialis, L.

Rough-stalked Meadow grass.

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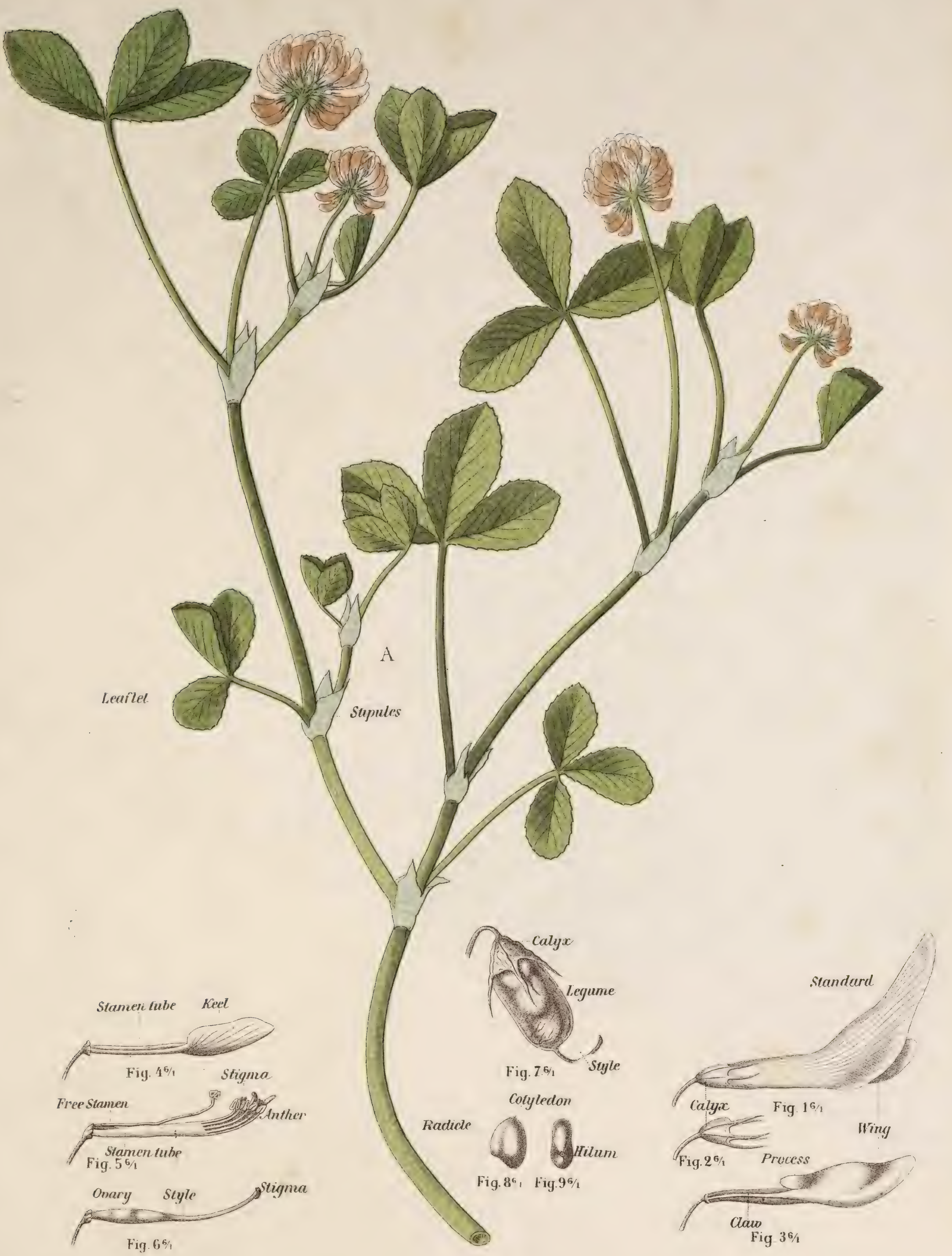

Trifolium hybridum, L.

Alsike Clover

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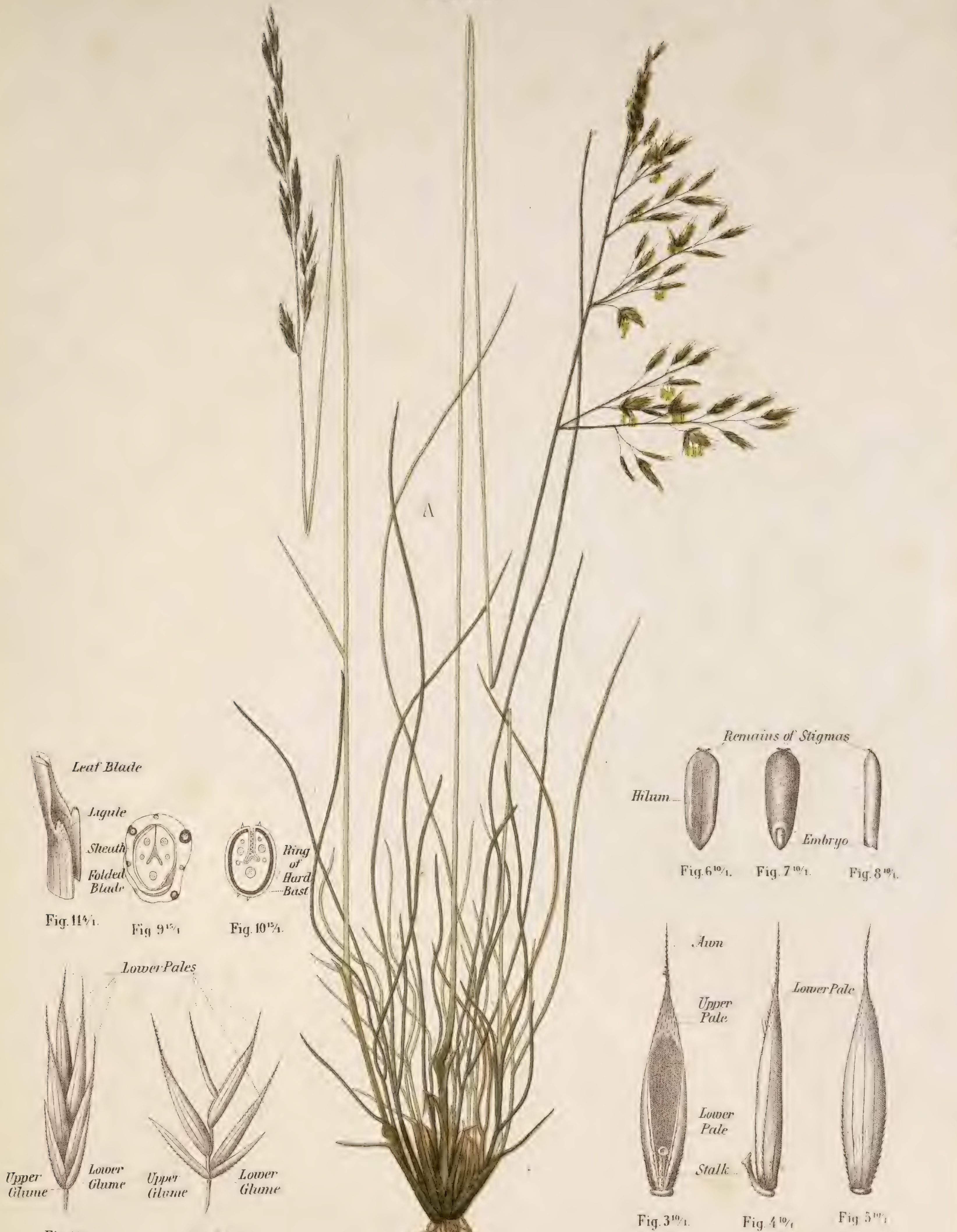
v. Lith. Genossenschaft Zürich.

Plate 16.

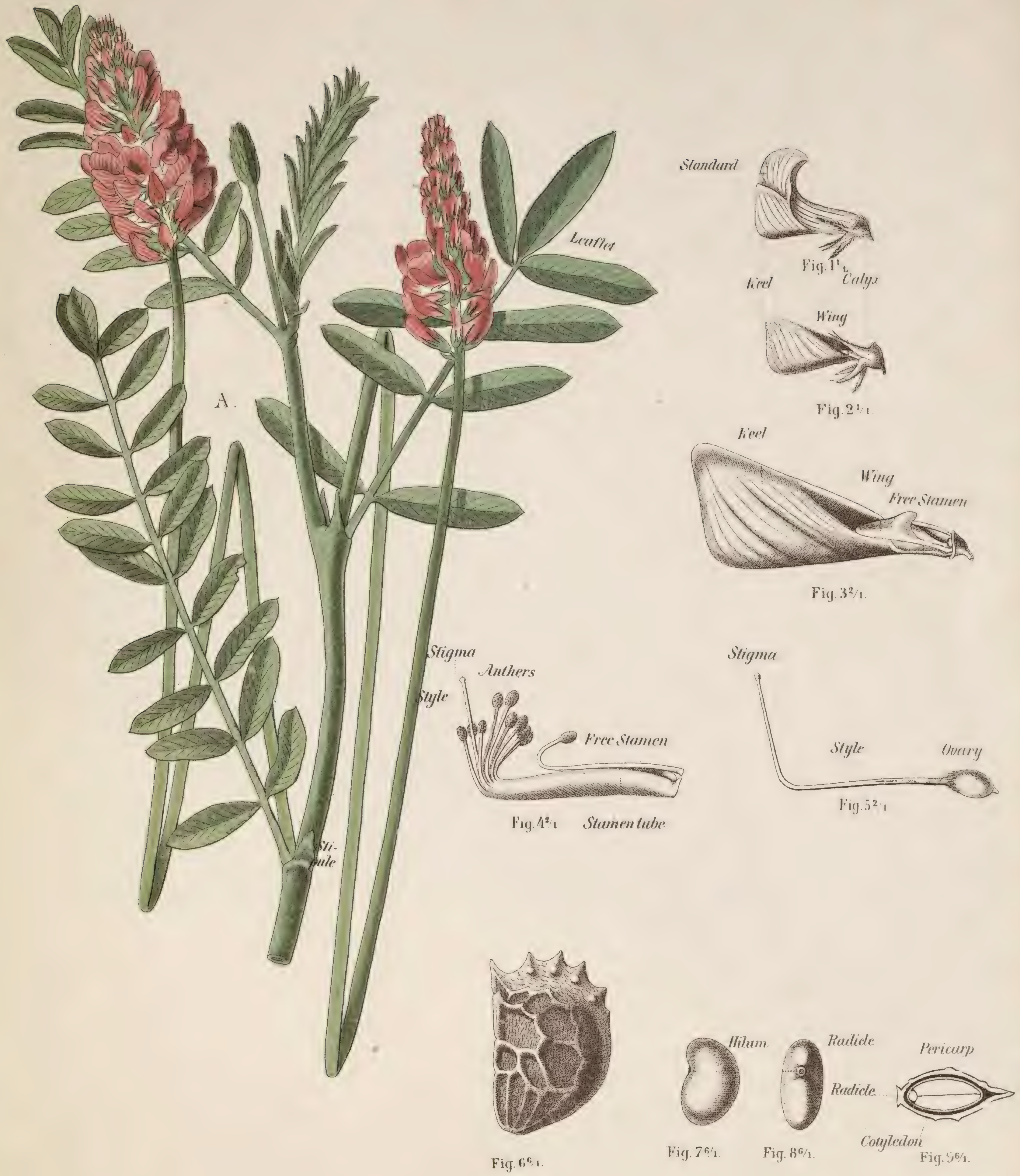


Festuca ovina, L. var. vulgaris, Koch.

C. & L. Schröter ad. nat. del.

Sheep's Fescue

Plate 17.



Onobrychis sativa, Lmk.

Sainfoin

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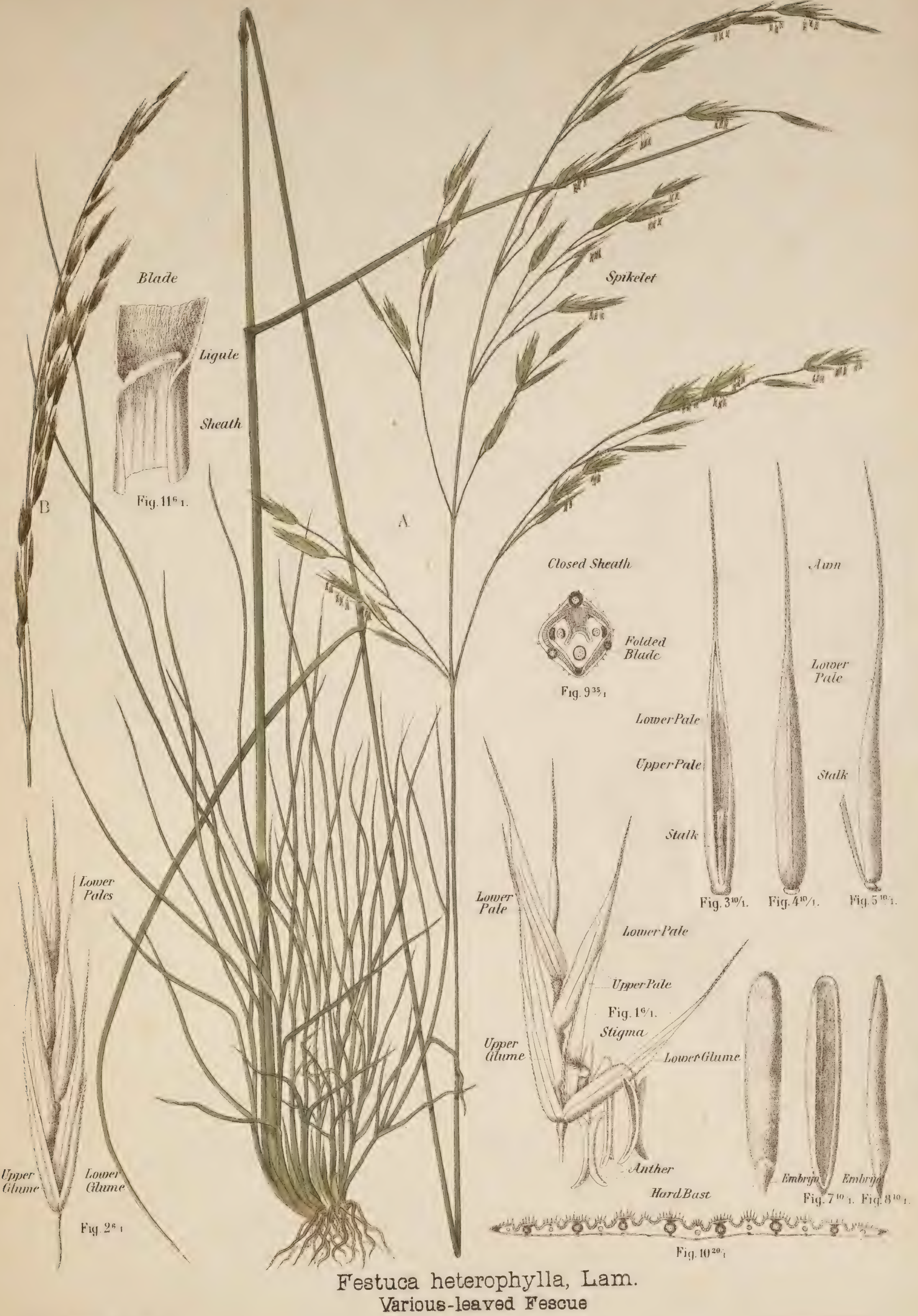
v Lith. Genossenschaft Zürich.

Plate 18.



Festuca heterophylla, Lam.
Various-leaved Fescue

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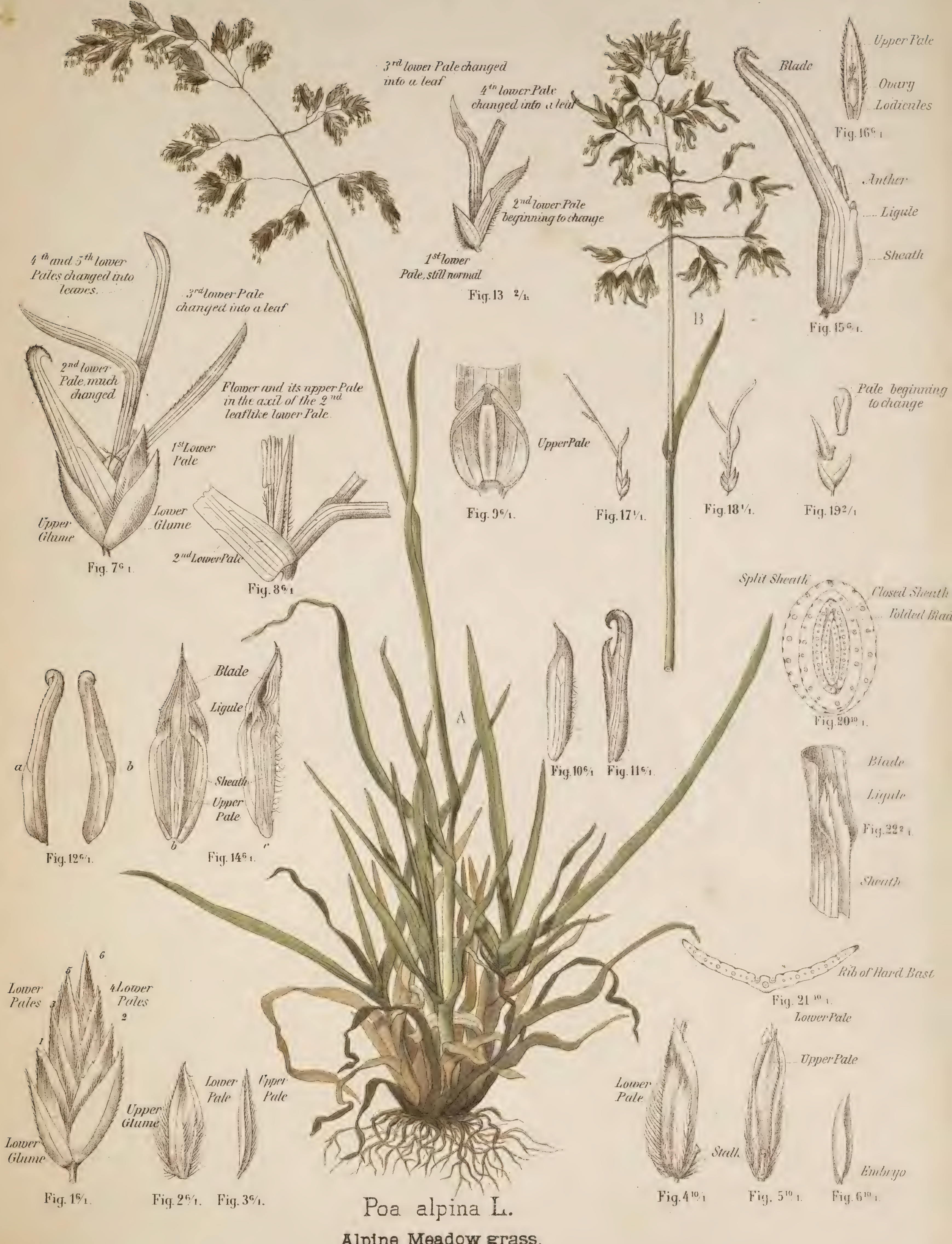
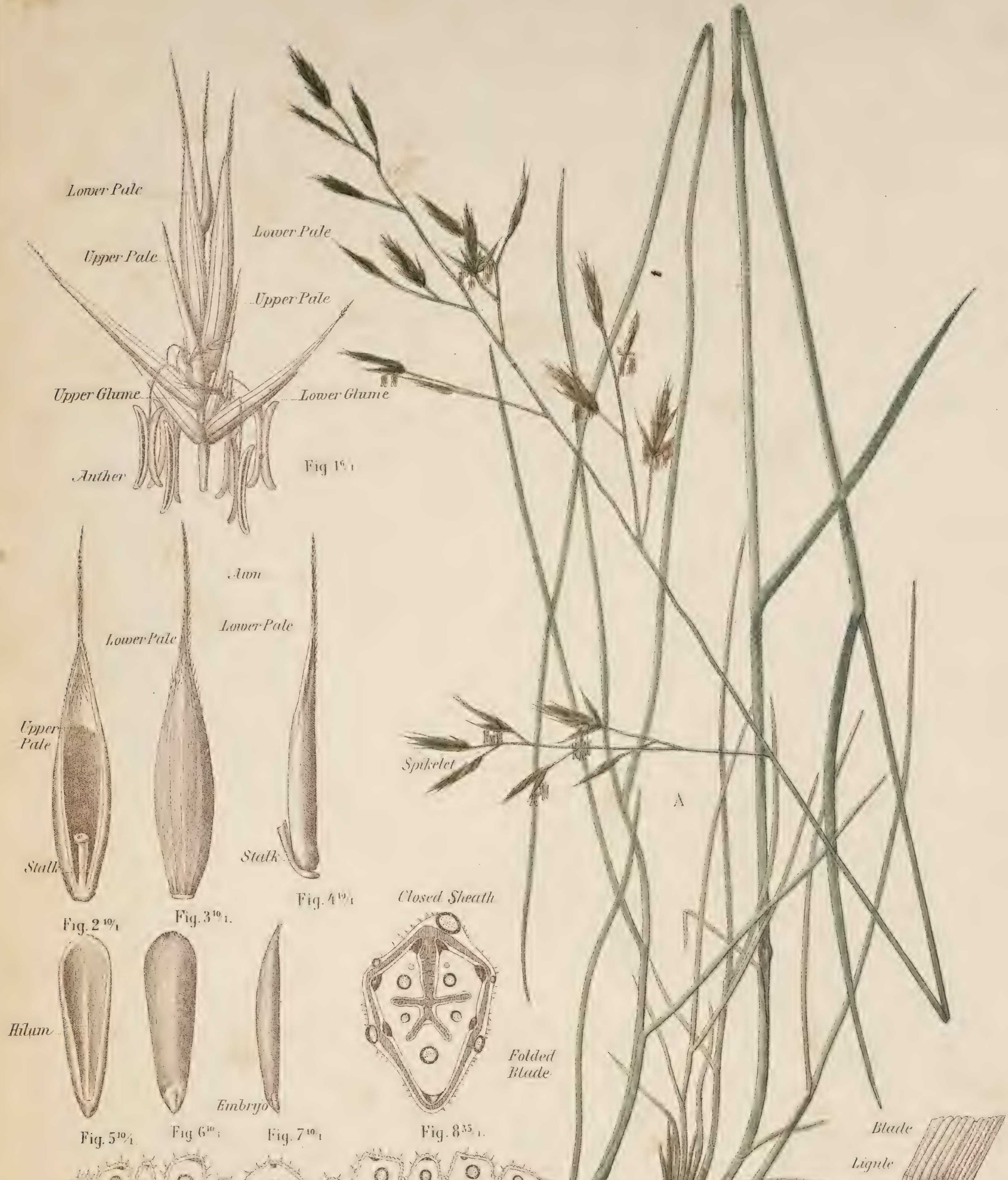
Plate 19.



Poa alpina L.

Alpine Meadow grass.

Plate 20.



Festuca rubra, L.

Creeping Fescue

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Plate 21.

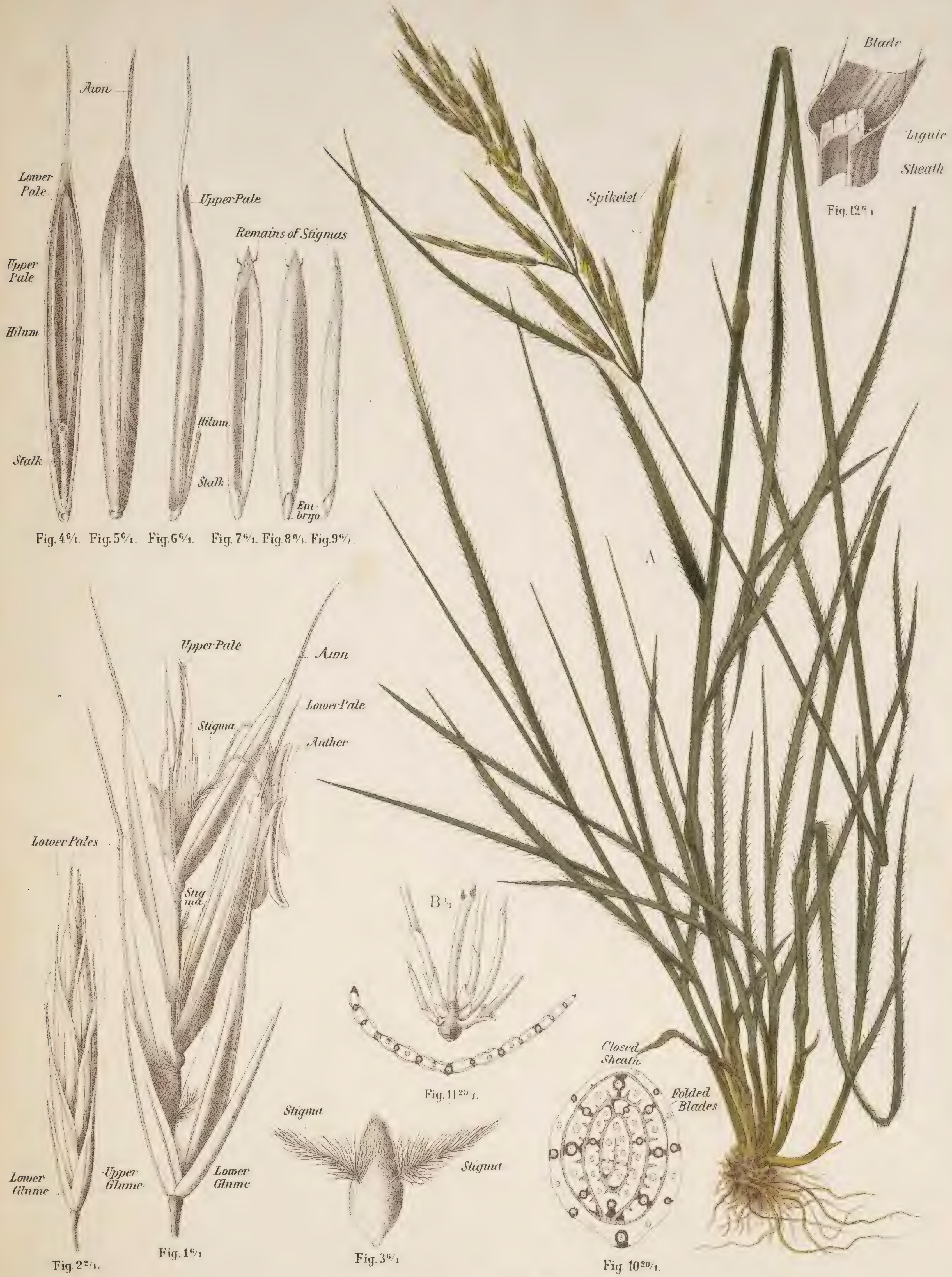


Fig. 12 6/1

Fig. 4 6/1. Fig. 5 6/1. Fig. 6 6/1. Fig. 7 6/1. Fig. 8 6/1. Fig. 9 6/1.

Fig. 11 20/1.

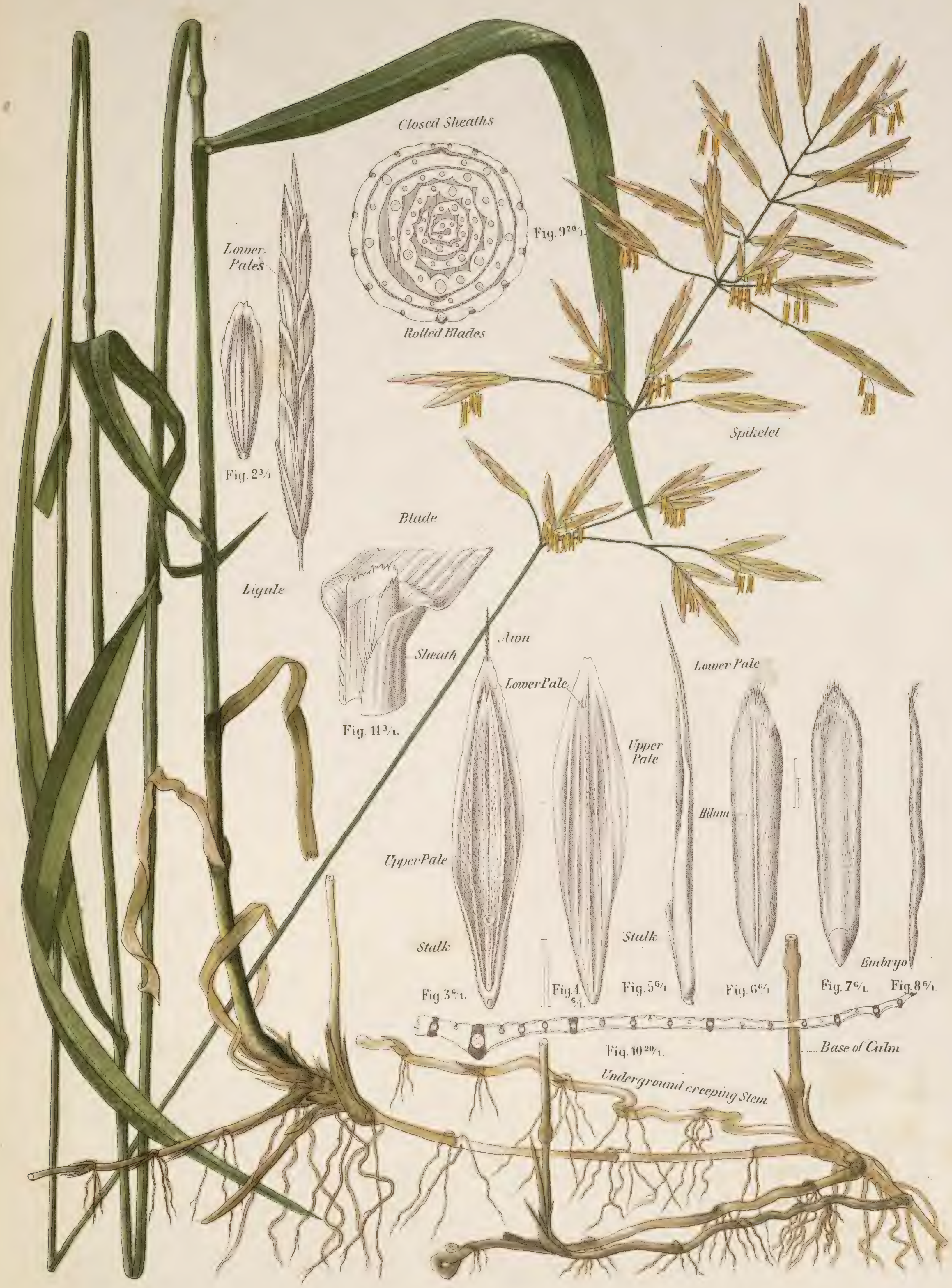
Fig. 2 2/1. Fig. 1 6/1 Fig. 3 6/1 Fig. 10 20/1.

Bromus erectus, Huds.

C. & L. Schröter ad. nat. del.

Upright Brome-grass.

Plate 22.



Bromus inermis. Leyss.

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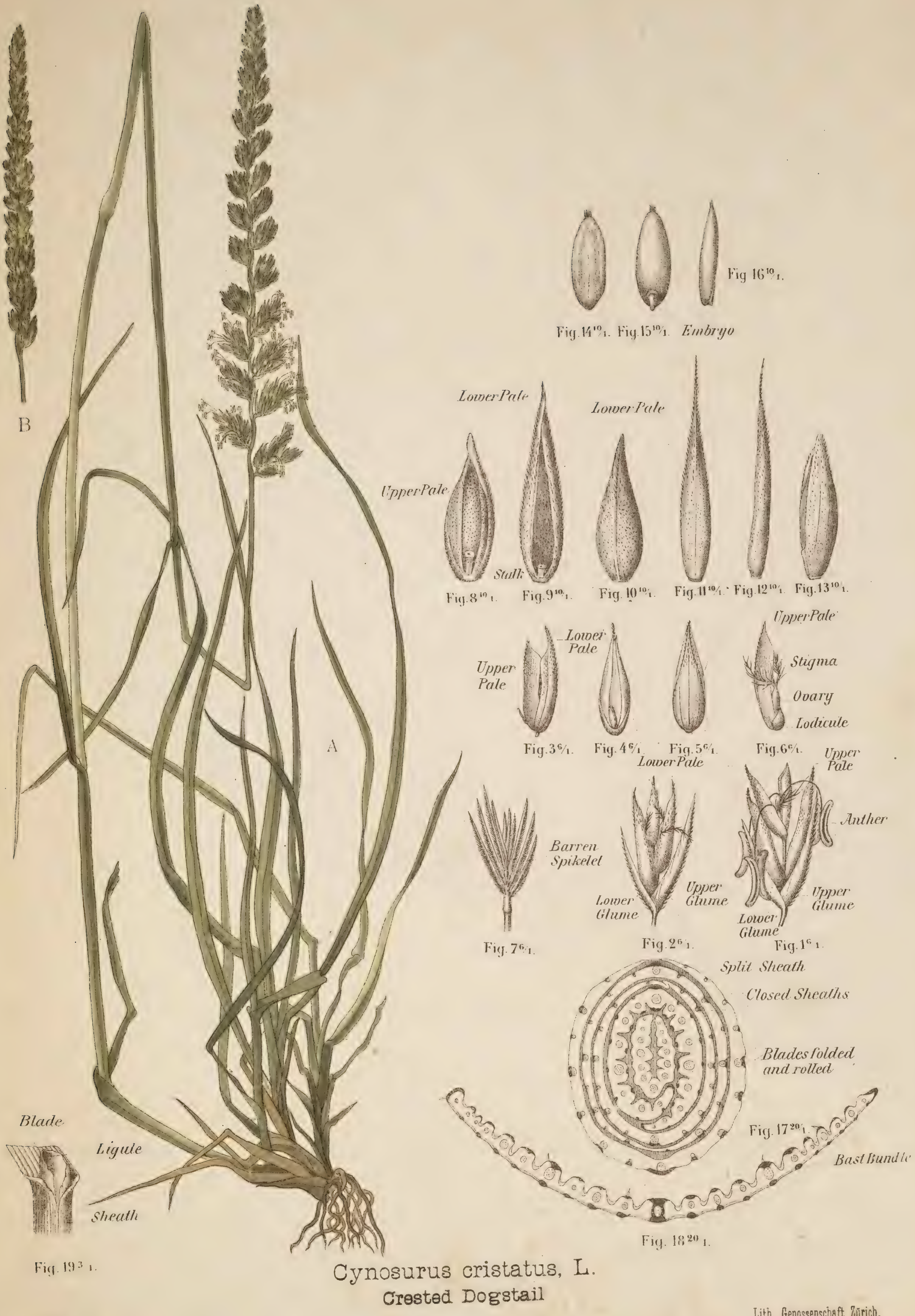
Awnless Brome-grass.

Plate 23.



Cynosurus cristatus, L.

Crested Dogstail

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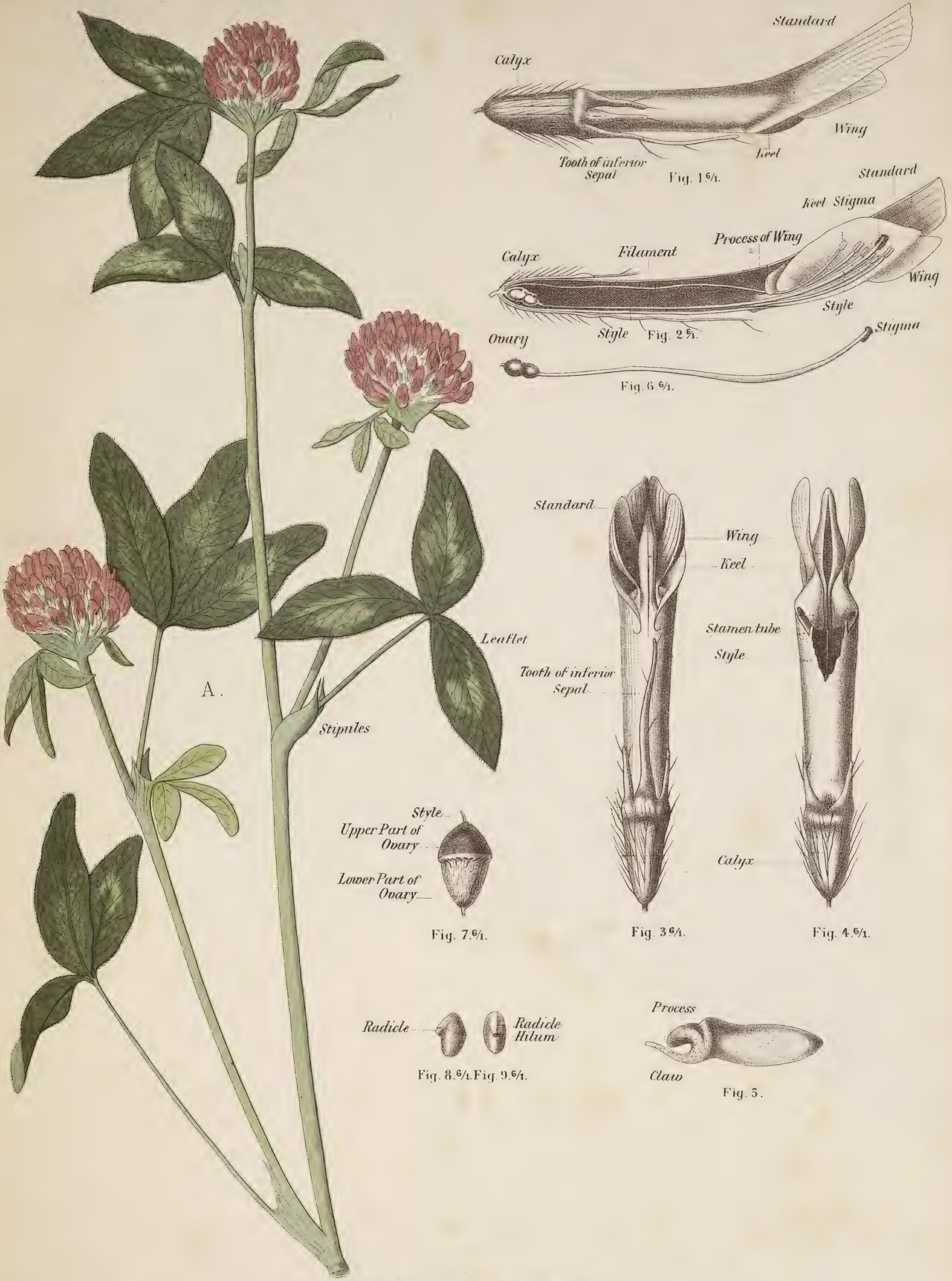
Plate 24.



Trifolium pratense, L.

Red Clover

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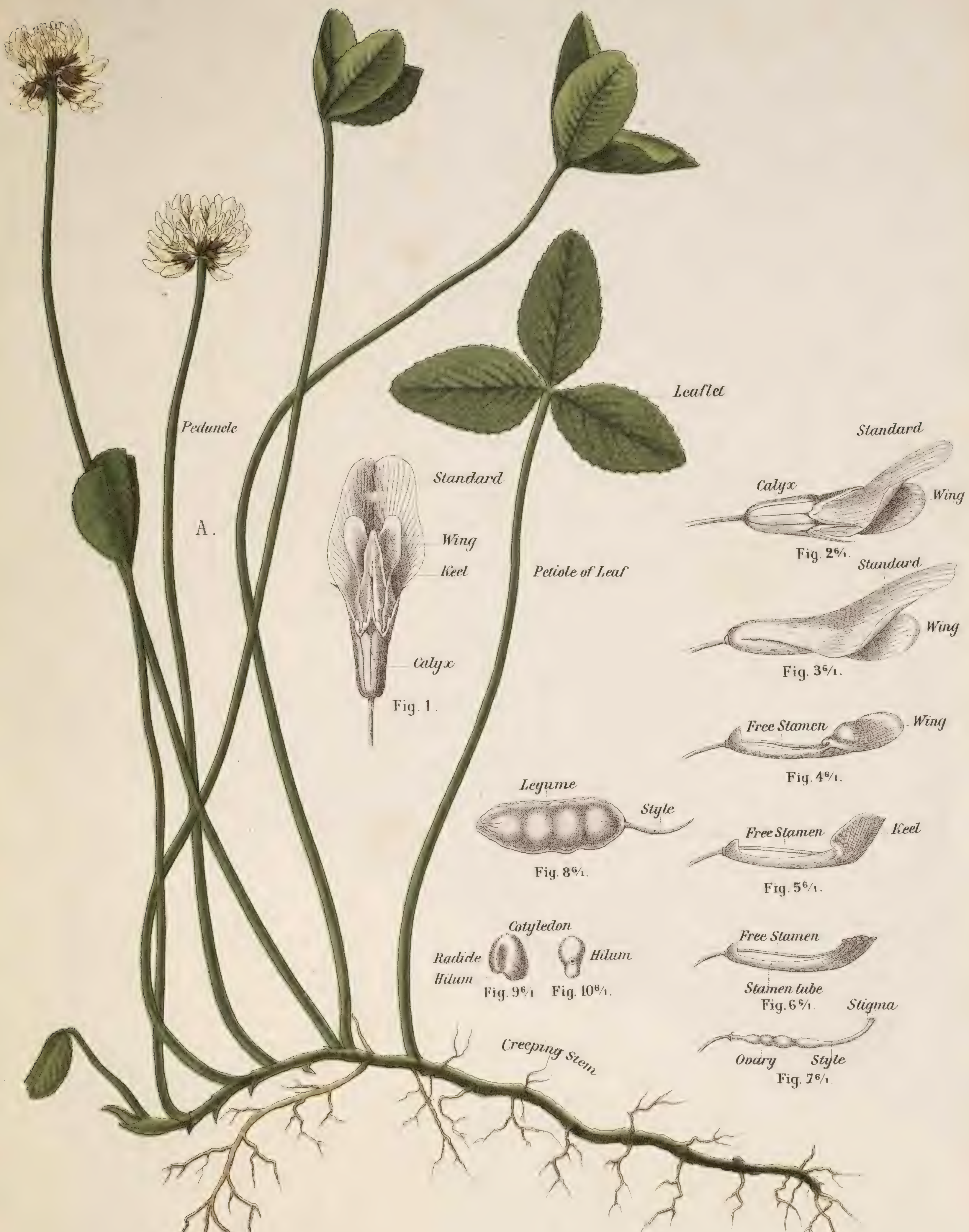
v. Lith. Genossenschaft Zürich.



Trifolium repens, L.

White Clover

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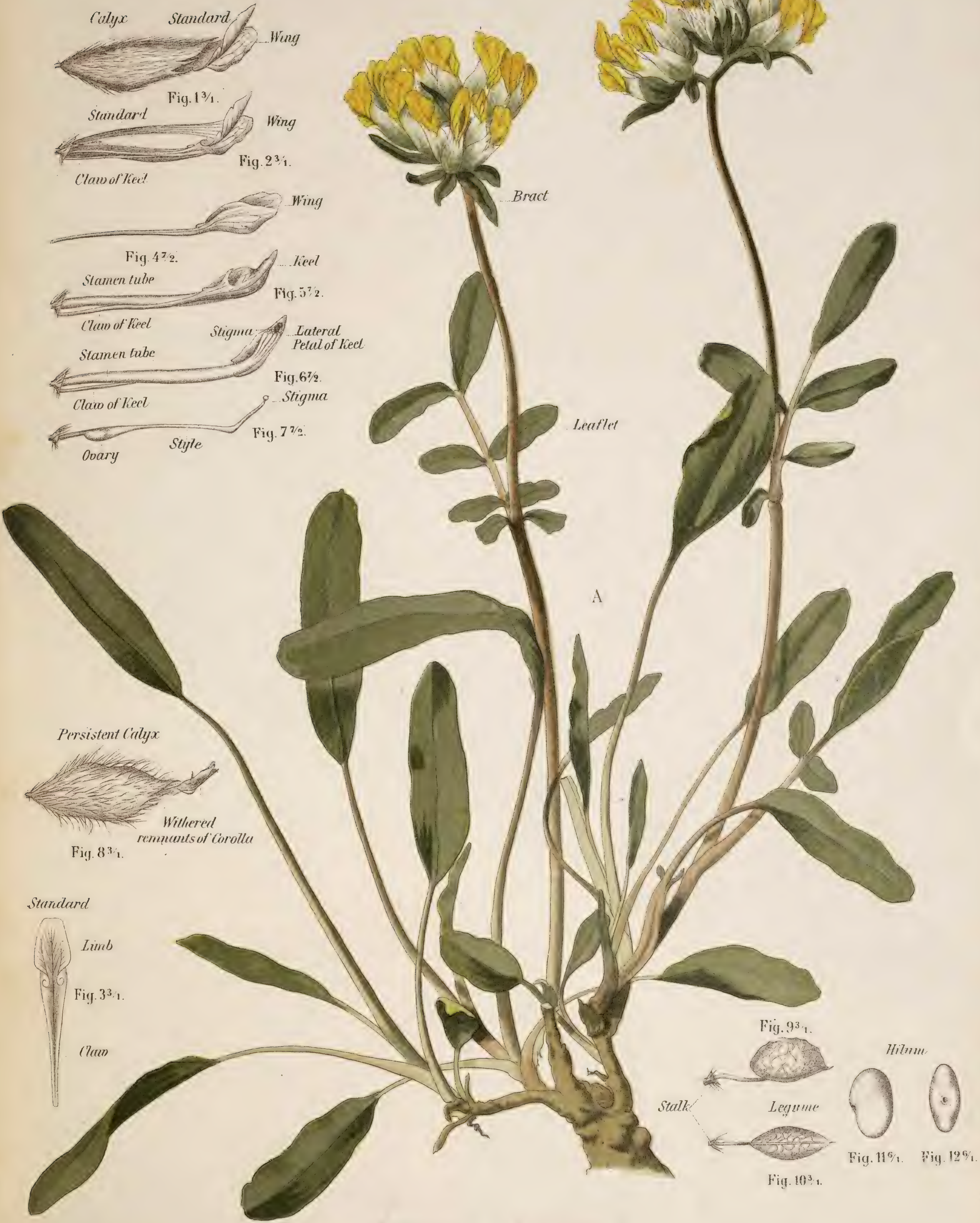
v. Lith. Genossenschaft Zürich.

Plate 26.



Anthyllis vulneraria, L.

Common Kidney Vetch.

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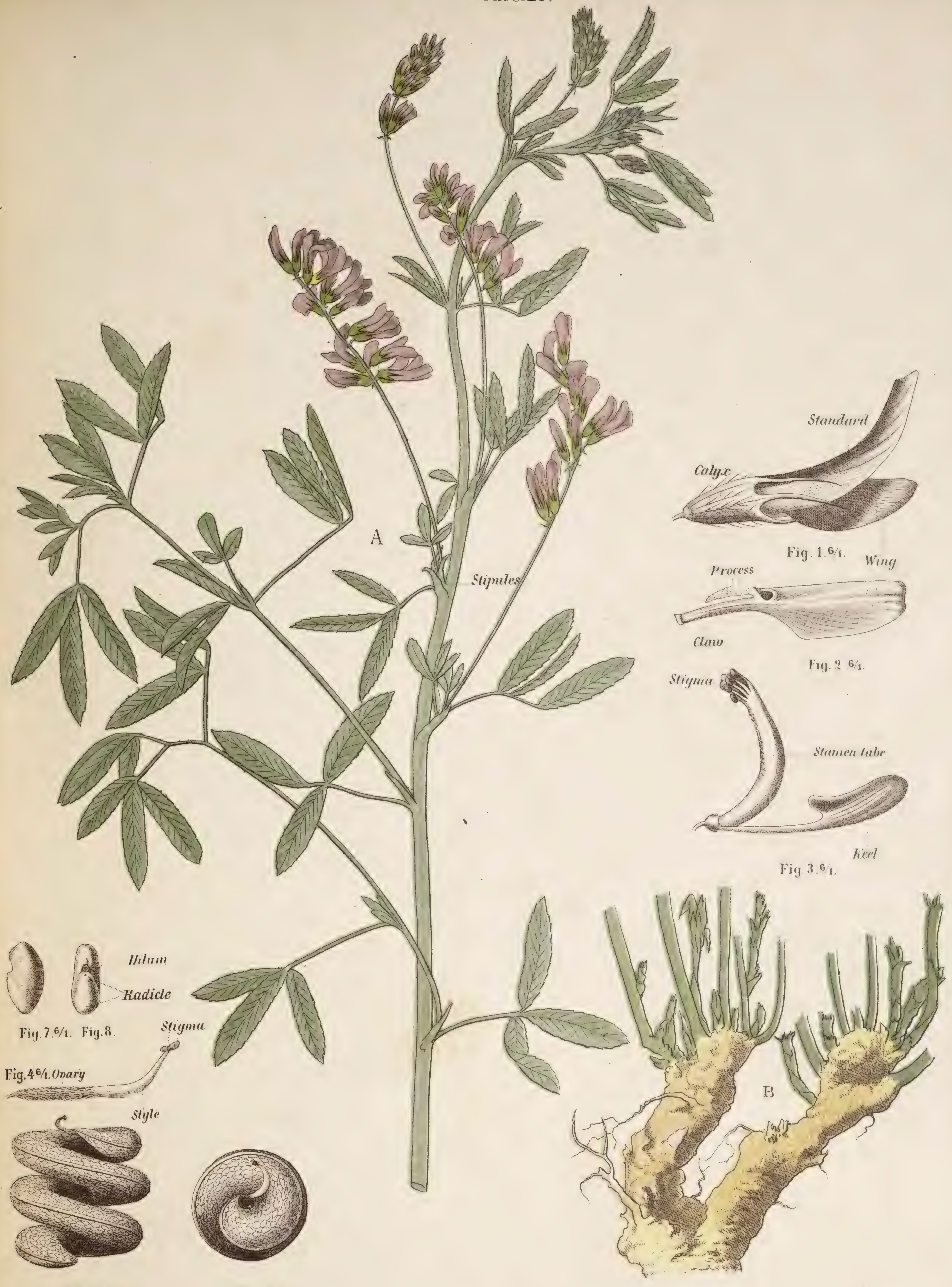
Plate 27.



Medicago sativa, L.

Lucerne

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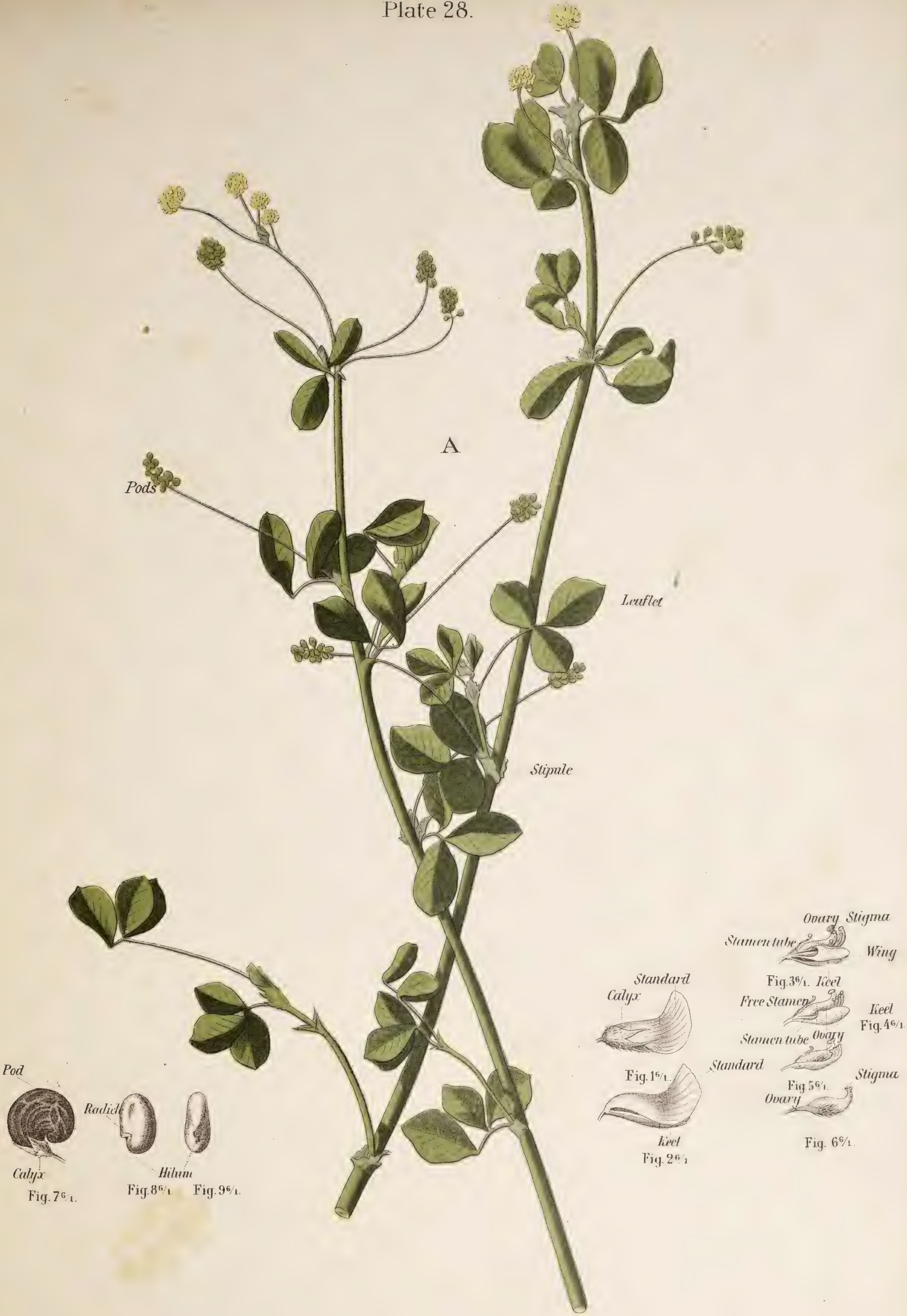
v. Lith. Genossenschaft Zürich.



Medicago lupulina, L.

Hop Trefoil.

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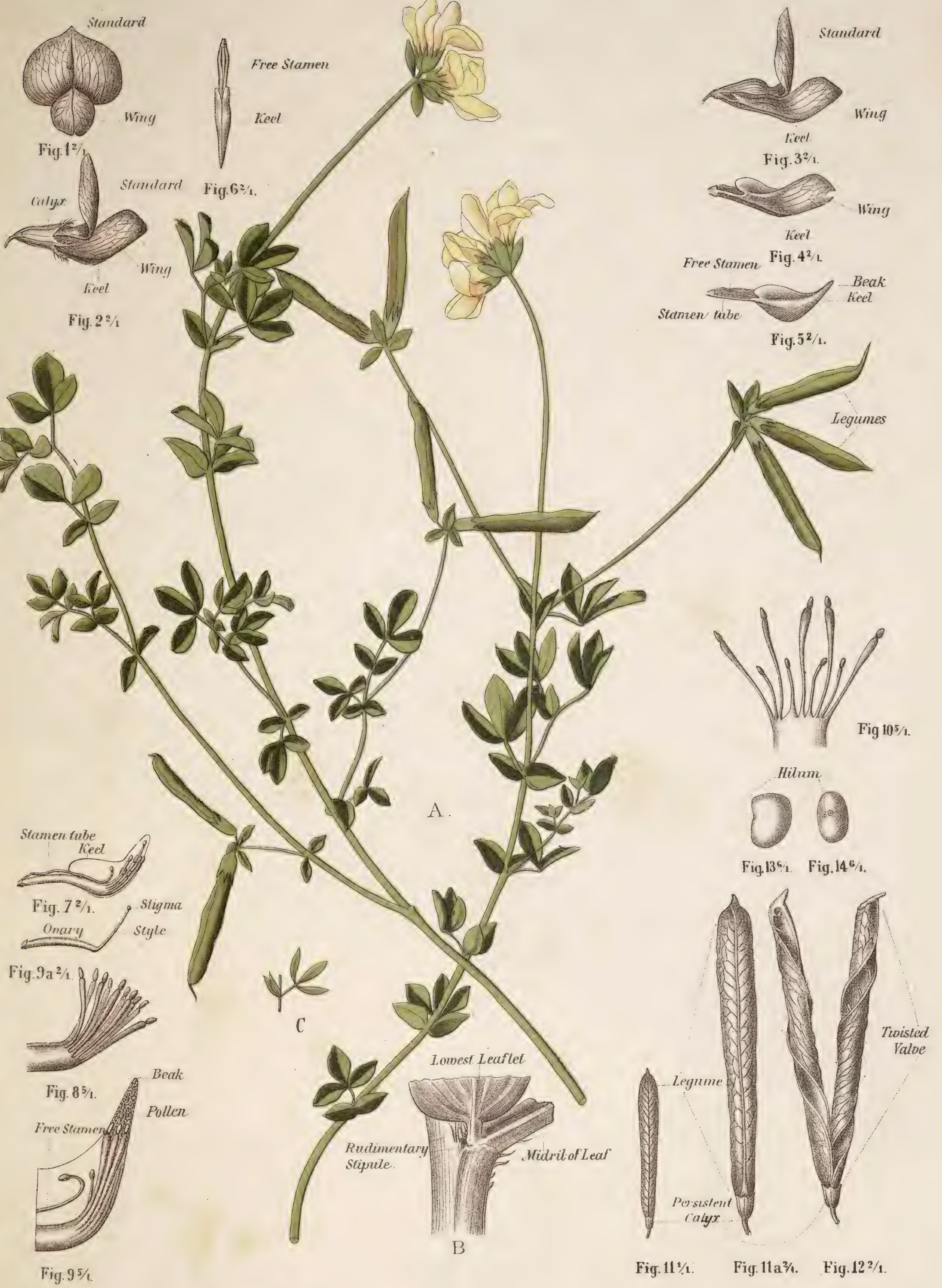
v. Lith. Genossenschaft Zürich.

Plate 29.



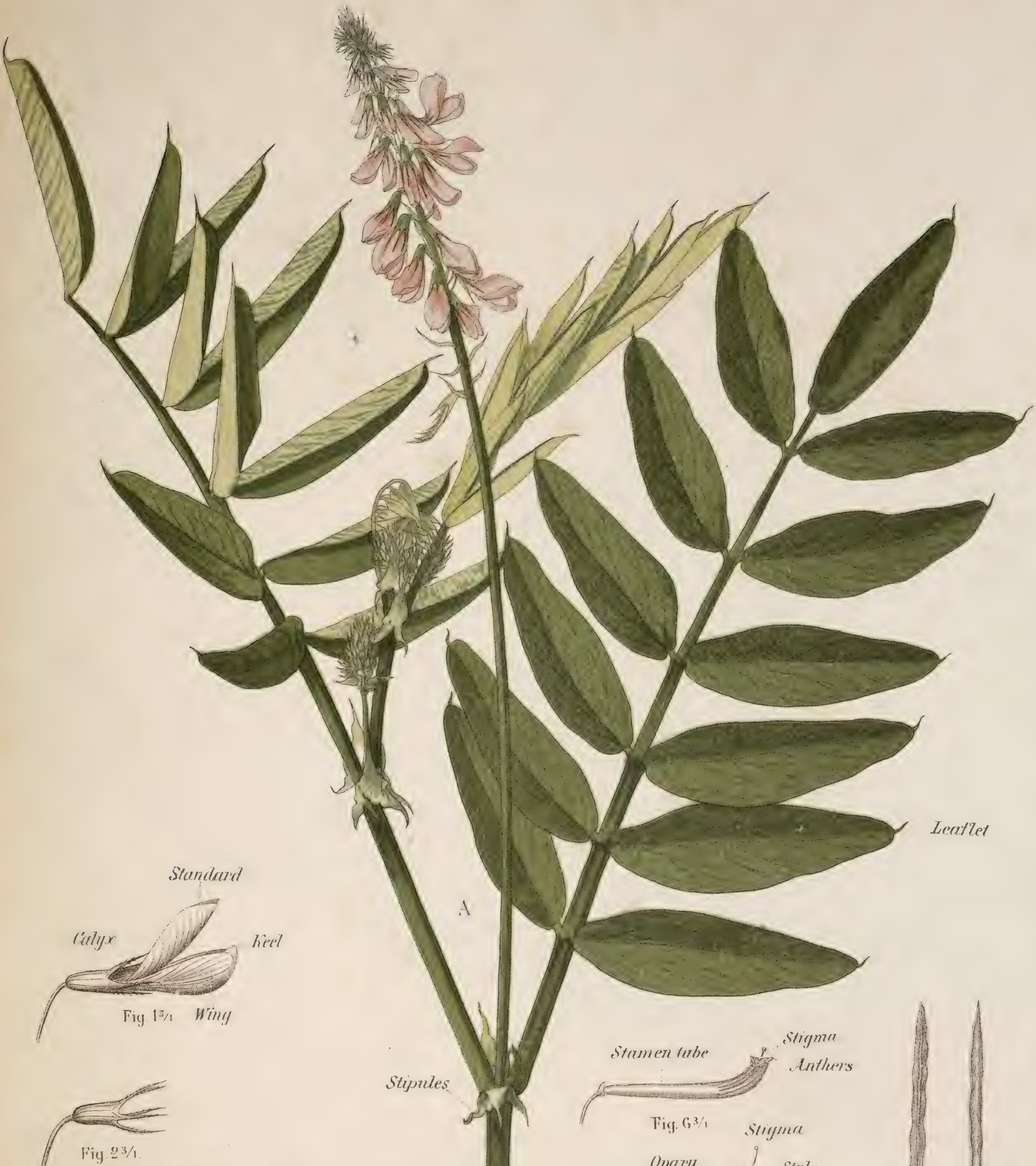
Lotus corniculatus, L.

Bird's-foot Trefoil

C. & L. Schröter ad. nat. del.

v. Lith. Genossenschaft Zürich.

Plate 30.



Galega officinalis, L.

Goat's Rue.

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